

# Corrosion

Official Publication  
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



VOL. 1

AUGUST 1949

No. 3



## NO-OX-ID *Cold Applied* PIPE COATINGS

### Offer Seven Positive Advantages

NO-OX-ID "GG," a chemically inhibited, pliable coating can be applied cold, by hand with canvas or leather-faced gloves, eliminating heavy equipment in the field. Its plastic consistency and adhesive strength permit it to contract and expand with the pipe. It bonds securely with one application of minimum thickness, provides high moisture resistance with no changes in physical or chemical composition.

With No. 4 NO-OX-IDized Wrapper, a high tensile strength, laminated, moisture-resistant fabric, the NO-OX-ID is kept in intimate contact with the pipe. A top coating of NO-OX-ID Filler Red "C" as a service coat, brushed on cold, assures a perfect three-way combination of the most positive underground pipe protection.

- ① Eliminate melting kettles, particularly advantageous in hilly country, rough terrain, or congested cities.
- ② No prime coat is necessary on new pipe.
- ③ Specially adapted for reconditioning used pipe.
- ④ Pliable, plastic consistencies do not deteriorate.
- ⑤ Pliability permits contraction and expansion with varying pipe temperatures.
- ⑥ Most conveniently used for maintenance and repair.
- ⑦ Chemical inhibitors provide positive corrosion protection.

"Piping Hot," a new 16mm sound movie in color on the use of hot applied NO-OX-IDs by stationary machine, is available to companies, engineering clubs or technical societies. Write for booking.

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IRON. RUST

**Dearborn**

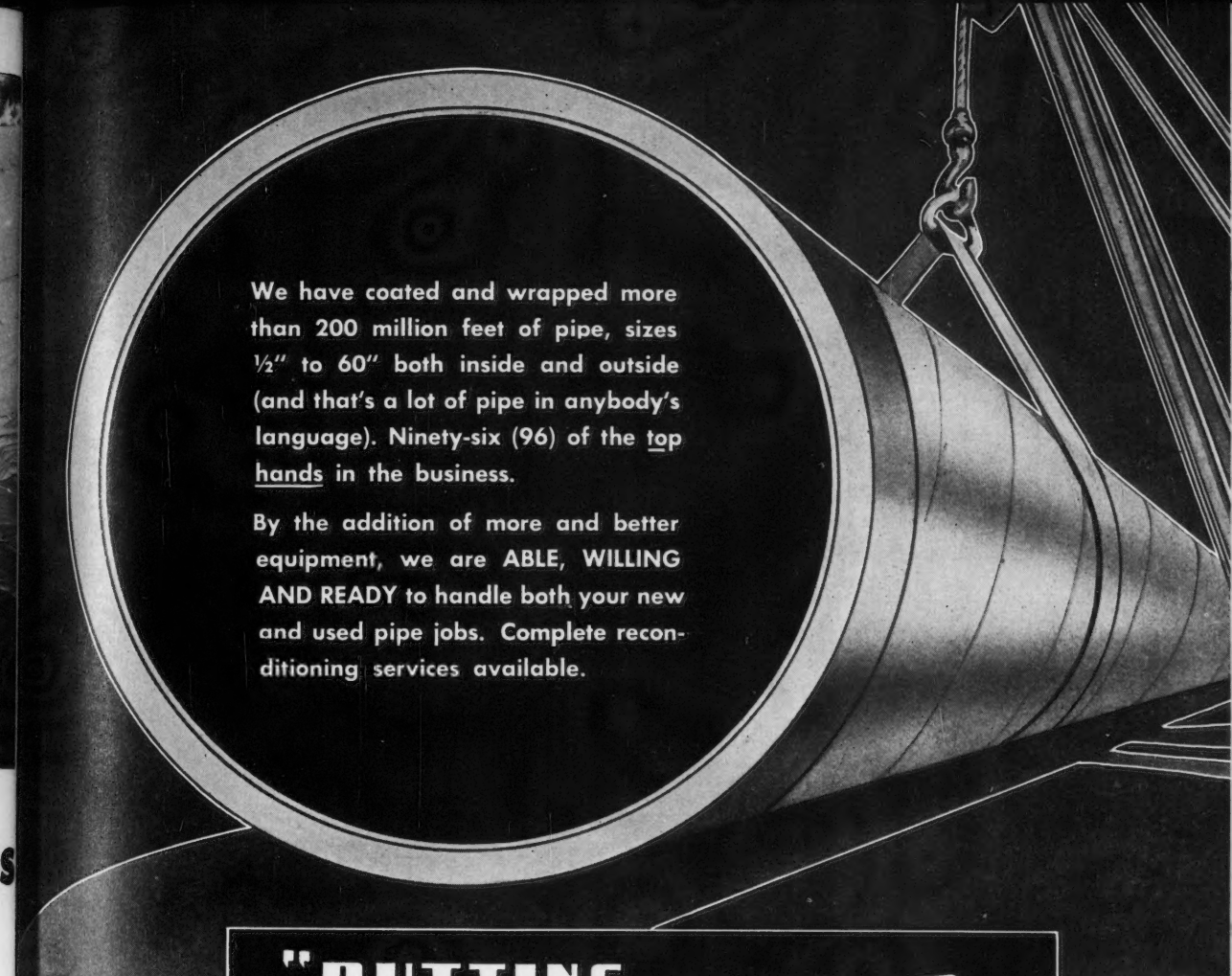
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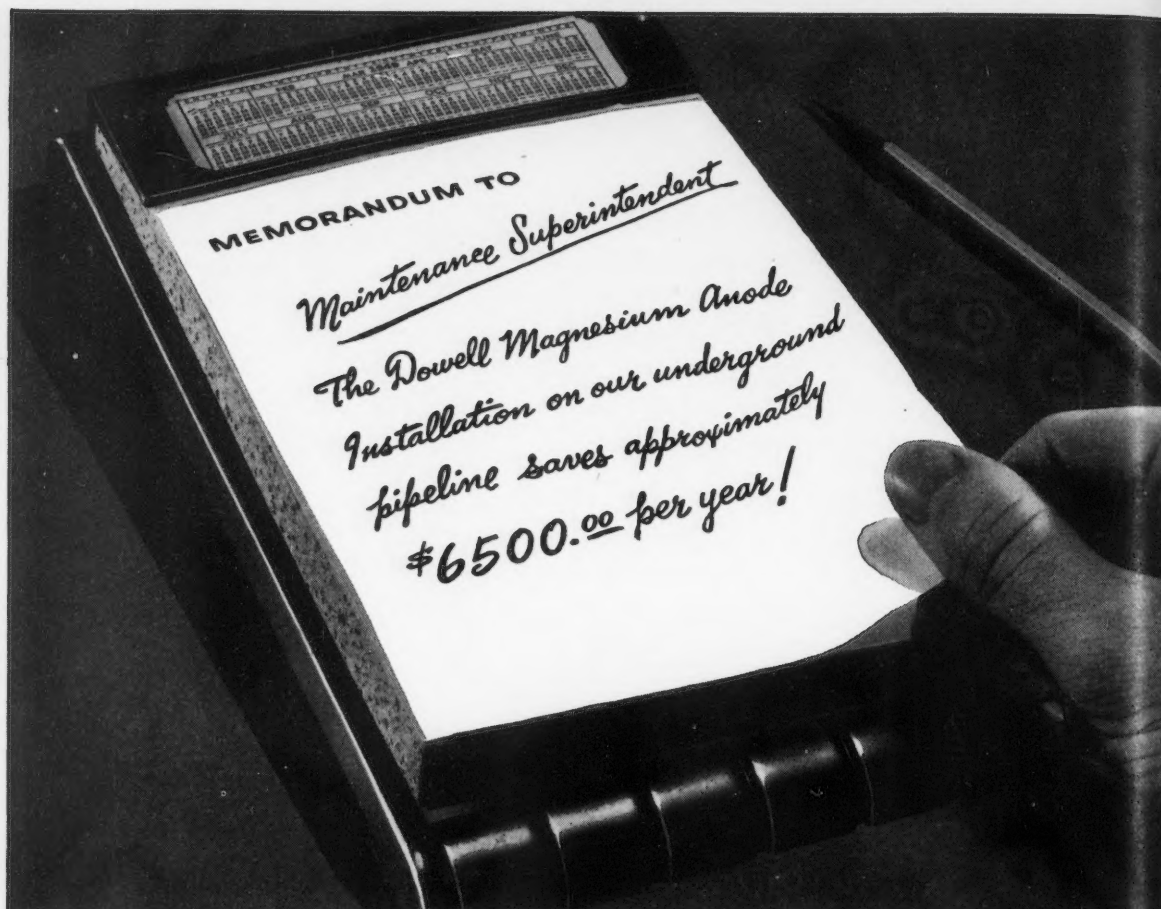
We have coated and wrapped more than 200 million feet of pipe, sizes  $\frac{1}{2}$ " to 60" both inside and outside (and that's a lot of pipe in anybody's language). Ninety-six (96) of the top hands in the business.

By the addition of more and better equipment, we are **ABLE, WILLING AND READY** to handle both your new and used pipe jobs. Complete reconditioning services available.

"PUTTING  
*Permanence*  
IN PIPE"

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**BROS.**  
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A subsidiary of The Dow Chemical Company—pioneer in the use of magnesium for corrosion control—Dowell offers the extensive research facilities and technical knowledge that make it your logical source of magnesium anodes. Write directly to Tulsa for additional information.

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#### FREE SHOWING!

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GALVO-PAK • GALVO-LINE

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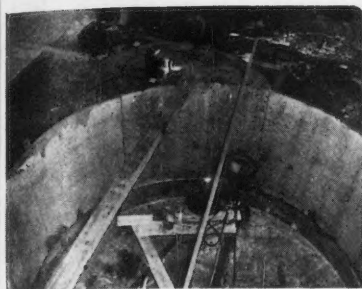


August, 1949—CORROSION

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equival...  
Entered...  
Post Off...  
1879...  
Corrosio...



THIS MONTH'S COVER—Operator is welding an alloy lining for the bottom girth seam of a partially field erected tank for storage of corrosive sulphite pulp cooking liquor. Success in using stainless steel alloy linings for severe types of corrosive service is credited to a careful testing program made under operating conditions. This installation was by the A. O. Smith Corp., Milwaukee, Wis.



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# Corrosion

devoted entirely to

## CORROSION

### Research and Control

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Vol. 5

AUGUST, 1949

No. 8



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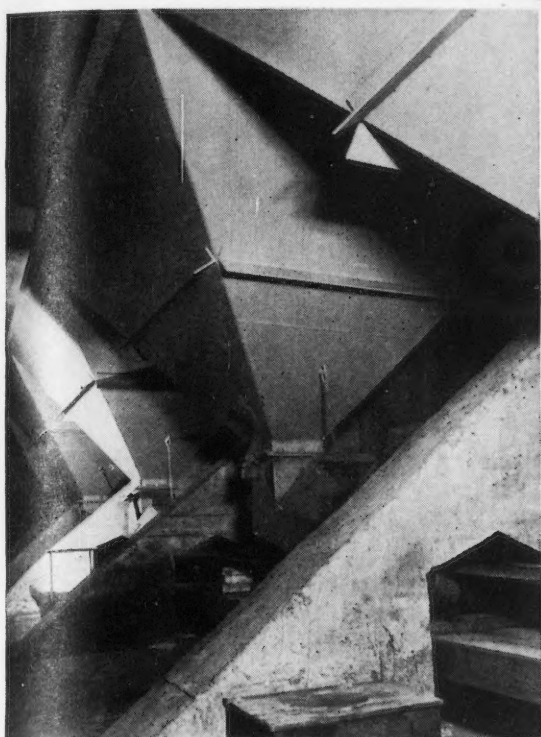
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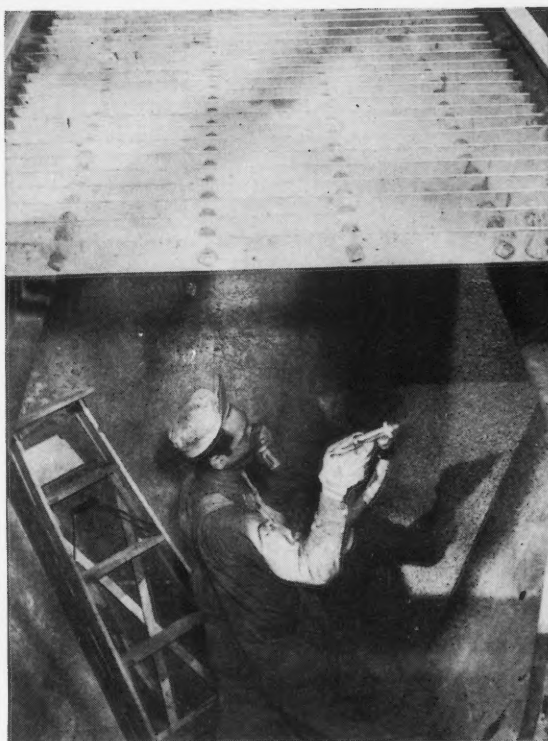
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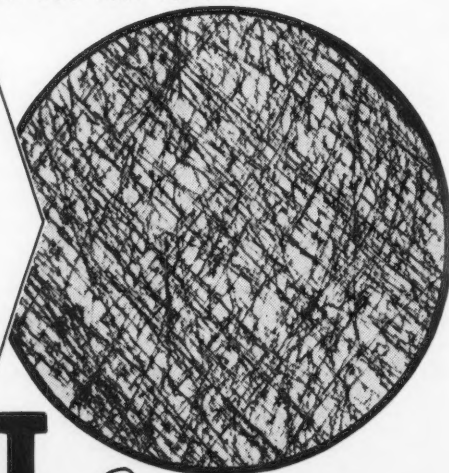
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CO.  
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3 **KAPCO  
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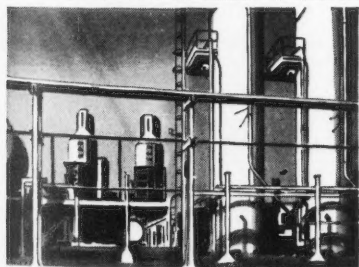
Control them systematically  
with UCILON Protective Coatings  
and the help of this booklet

Users of Ucilon coatings are acclaiming this systematic method for controlling corrosion as they report getting longer life from equipment plus lower maintenance costs. It may be the practical answer to your own problem.

First, we send you this 32-page booklet. It lists common agents responsible for failures of ordinary paints and the subsequent corrosion of equipment. For each of the 153 agents listed, it presents a recommended system of Ucilon protective coatings for use against the specific trouble—one which has proved it can lick the corrosion problem to a "standstill." There are systems that resist acids, alkalies, salts, oils, water, organic materials.

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U.C.I. Bulletin U-5a, Page 2

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U.C.I. Bulletin U-5a, Page 3

FOR GENERAL RESISTANCE TO:

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E	E	B.E
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J.F	J.F	E.B
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J.P	J.P	J.P
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CORROSION—August, 1949



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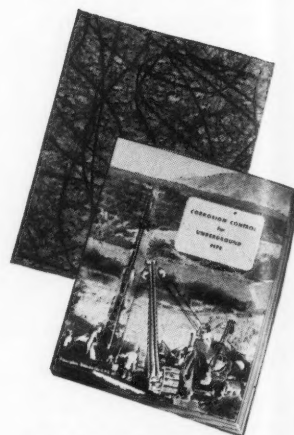
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CORROSION



# Technical Committee Activities

## Procedures Outlined For Cathodic Protection Minimum Current Data Experiments

By A. V. SMITH\*

On July 19, 1948, a questionnaire was sent to all members of the association requesting certain information regarding the use of cathodic protection. From the results of this questionnaire it was hoped by the sub-committee that a criterion for the minimum current required for cathodic protection would be apparent. Actually the questionnaire replies showed a wide diversity of answers and no critical methods were proved to determine the minimum current required for cathodic protection. It was further apparent from the replies that, while cathodic protection was successful, it was probable that in many cathodic protection installations the current used for this protection was in excess of the required current.

Since a criterion for the minimum current required for cathodic protection was not available from the questionnaire replies and since a proved criterion might effect economies in the use of cathodic protection, it was evident that properly designed and controlled experiments would be necessary to give the answer to this problem. The general details of the experiments required are as follows:

- a. A Constant current experiment should be developed in which the tested specimens are provided with fixed protective currents. The number of specimens for each current value should be selected so that statistical evaluation of the averages is obtained from the weight loss data. With the current held constant observation should be made of each specimen's polarization and of its resistance, both as a function of time.

- b. An experiment should be developed in which test specimens are subject to a fixed applied electrical field such as is established between electrodes in the ground between which current is applied. Specimens should be small enough so that inter-specimen coupling and specimen current drains are negligible in their effect on other specimens and on the applied field. Observations should be made of the variation of each specimen current drain with time, and of the variation of polarization and surface resistance with time.
- c. An experiment should be developed in which test specimens are observed by means of automatic apparatus in which IR drops are so compensated that polarization EMF is observed. Apparatus should be developed to control the protective current so that the polarization EMF is maintained at a pre-determined value. Observations of current requirements and specimen resistance should be made as a function of time.

Performance of these experiments poses quite a problem of instrumentation and control. Dr. J. M. Pearson was appointed chairman of a sub-committee to lay out the procedures for these experiments, including instrumentation and control.

When these procedures have been developed it is proposed to solicit assistance from industries and the universities in carrying out the actual experiments in whole or in part in various sections of the country. Since the procedures will be set up so all may follow the same path giving comparable results it is hoped that results of the experiments will not only indicate a criterion or criteria for the minimum current required for cathodic protection, but will disclose the actual importance of the various phases of measurement and provide cathodic protection engineers with reliable tools in the use of cathodic protection.

\* Chairman, TP-4 Committee on Minimum Current Requirements for Cathodic Protection.

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(a) to promote scientific research in determining the causes of corrosion and methods of its control with respect to theory and practice.

(b) to provide a means of exchange of knowledge and ideas among those individuals actively engaged in the control of corrosion.

(c) to promote methods of control of corrosion.

(d) to promote standardization of terminology, methods, equipment and design in the development of methods of corrosion control.

(e) to foster cooperation between individual owners of metallic structures in the solution of their joint corrosion problems.

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# Comparative Corrosion Resistance of Some Copper Alloy Condenser Tubes ★

By JOHN R. FREEMAN, JR.,\*\*  
and  
A. W. TRACY\*



Figure 2—Inlet end of condenser, approximately  $\frac{1}{3}$  natural size.

THE DEVELOPMENT of superior alloys suitable for use as condenser tubes in large, tubular condensers has been the subject of intensive research for many years. Service in shipboard condensers and at tidewater power plants is particularly severe as a consequence of the corrosive qualities of sea water.

Alloys to be used in condenser tubes must be resistant not only to corrosion by the sea water but also to the well-known phenomenon of impingement attack resulting from aeration of the sea water and relatively high-velocity flow of the aerated sea water through the condenser tubes, particularly on shipboard.

Corrosion tests can be made in a laboratory to determine the relative, fundamental corrosion resistance of various alloys. Many tests also have been devised to show the effect of velocity of flow and aeration on condenser tube alloys. There is always the question, however, of extrapolating laboratory test data into probable service results. Very few direct, comparative data are available.

In 1931, the authors devised an experimental test condenser for laboratory study of condenser tubes to determine their relative resistance to corrosion in sea water. This work was reported to the ASME Special Research Committee at the December meeting in 1932.

During the war period, extensive laboratory studies were made to determine the effect of iron on the resistance to impingement of the cupro-nickel alloys. This work was reported in 1945.<sup>1</sup> It was found that an alloy of 10% nickel, about 0.75% iron and remainder copper showed excellent resistance to corrosion by impingement attack, comparable to the

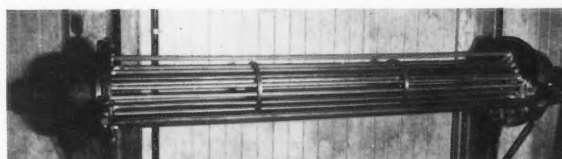
Position	ALLOY
1-9	Arsenical Admiralty 439.
2-10	Ambraloy 927 (Aluminum Brass).
3-11	Super-Nickel 701 (Low-Iron 70-30 Cupro-Nickel).
4-12	Super-Nickel 702 (High-Iron 70-30 Cupro-Nickel).
5-13	Ambraloy 901 (95-5 Aluminum Bronze).
6-14	10 Percent Cupro-Nickel 754 (High Iron 90-10 Cupro-Nickel).
7-15	8 percent Phosphor Bronze 353.
8-16	Plain Admiralty 442.

well-known super-nickel alloy containing 70% copper and 30% nickel. This was confirmed by tests in the experimental condenser, using synthetic sea water made from Turks Island sea salt.

Tests under simulated service conditions, using fresh, clean or polluted sea water, were desirable to check the laboratory findings.

The possibility of setting up the experimental condenser at the Kure Beach marine test station of the International Nickel Company presented itself and through the courtesy of Mr. Frank LaQue, this was arranged.

Complete assembly



Note glass tube (top) to observe flow of water and aeration

Water boxes removed

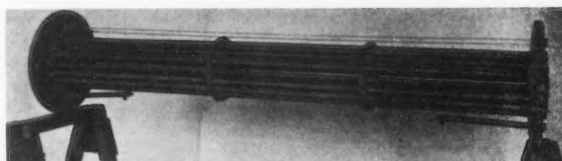


Figure 1—Experimental condenser. (Approximately  $\frac{1}{27}$  actual size).

★ Voluntarily submitted for Publication July, 1949.

\* Technical Manager and \*\* Assistant Metallurgist, The American Brass Company, Waterbury, Conn.



Figure 3—Upper left quadrant. 1. Arsenical Admiralty 439. 2. Ambraloy 927 (aluminum brass). 3. Super-nickel 701 (low-iron 70-30 cupro-nickel). 4. Super-nickel 702 (high-iron 70-30 cupro-nickel).

The test condenser is shown in Figure 1. It was the same as used in laboratory tests. The tubes are  $\frac{5}{8}$ -inch O.D. by 0.049-inch gauge by 61 inches long and are held in the tube plates by plain Admiralty ferrules in such a way that the ends of the tubes extend into the water boxes beyond the ends of the ferrules. This condition exposes the inlet ends of the tubes to turbulent water flow. This method of tube installation would not be considered good practice in service but helps to magnify the corrosive conditions of the test. The tube plates are Everdur 1010 although this alloy ordinarily is not considered for tube plates exposed to sea water. The water boxes were made from drawn shells of 70-30 cupro-nickel.

See Figure 2 for arrangement of tubes.

The compositions of these tubes by analysis are given in Table 1.

The experimental condenser was fastened to the outside of the rear wall of the pump house at the test basin. Sea water from the basin was pumped to

a tank on the roof of the pump house, about 25 feet above the condenser from where it dropped by gravity to the condenser. The water flowed through the tubes at an average velocity of 11.7 feet per second. The sea water was high in dissolved air but was practically free from air bubbles as it flowed through the condenser. No attempt was made to heat the condenser or the water. The normal temperature of the sea water varied from 45° F. to 85° F. depending on the season of the year. The test was continued for ten months, from July 28, 1947 to May 25, 1948.

The general condition of the inlet ends of the tubes after ten months test carrying highly turbulent sea water can be seen in Figure 2. More detailed views of the inlet ends of the tubes are shown in Figures 3-6.

Figure 3 shows the condition of the four tubes in the upper left-hand quadrant of the condenser as follows:

**Tube No. 1—Arsenical Admiralty 439**

Inlet end corroded away for a distance of about  $\frac{1}{4}$  inch. Thinning and pitting has taken place along the tube for a distance of about three inches. The remainder of the tube is relatively uncorroded.

**Tube No. 2—Arsenical Aluminum Brass (Ambraloy 927)**

Inlet end thinned and roughened and tube pitted for distance of about one inch along inside wall. Remainder of tube relatively uncorroded.

**Tube No. 3—70-30 Cupro-Nickel, Low-iron (Super-Nickel 701)**

Very slight roughening on inlet end. Remainder of tube in excellent condition.

**Tube No. 4—70-30 Cupro-Nickel + 0.4% Iron (Super-Nickel 702)**

Inlet end very slightly roughened. Rest of tube in excellent condition.

Figure 4 illustrates the condition of the four tubes in the lower left-hand quadrant of the condenser.

**Tube No. 5—Aluminum Bronze 95-5 (Ambraloy 901)**

The inlet end has corroded away in part for a distance of about  $\frac{1}{16}$  inch and the inside wall of the tube is pitted along a distance of 1 inch. One pit extends through the wall of the tube. The rest of the tube relatively uncorroded.

**Tube No. 6—90-10 Cupro-Nickel + 0.75% Iron (Cupro-Nickel 754)**

Slightly roughened on inlet end for distance of one inch along wall of tube. Remainder of tube in excellent condition.

Table 1—Analysis of Tubes

	Copper Percent	Zinc Percent	Iron Percent	Tin Percent	Arsenic Percent	Lead Percent	Aluminum Percent	Manganese Percent	Nickel Percent	Phosphorus Percent
Arsenical Admiralty 439.....	70.98	27.92*	0.01	1.04	0.032	0.02	.....	.....	.....	.....
Aluminum Brass (Ambraloy 927).....	76.94	21.04*	0.03	.....	0.04	0.005	1.94	.....	.....	.....
70-30 Cupro-Nickel, low iron (Super-Nickel 701).....	68.89	0.10	0.03	.....	.....	.....	.....	0.57	30.41*	.....
70-30 Cupro-Nickel, high iron (Super-Nickel 702).....	68.05	0.30	0.45	.....	.....	.....	.....	1.25	29.95*	.....
Aluminum Bronze (Ambraloy 901).....	94.81	0.20	0.09	.....	.....	.....	4.90*	0.12	9.69*	.....
90-10 Cupro-Nickel, high iron (Cupro-Nickel 754).....	89.21	0.17	0.80	.....	.....	0.004	.....	.....	.....	.....
Phosphor Bronze 353.....	91.63	0.00	0.008	8.20	.....	0.01	.....	.....	.....	0.15
Uninhibited Admiralty 442.....	70.44	28.42*	0.01	1.12	.....	0.005	.....	.....	.....	.....

\* By difference.

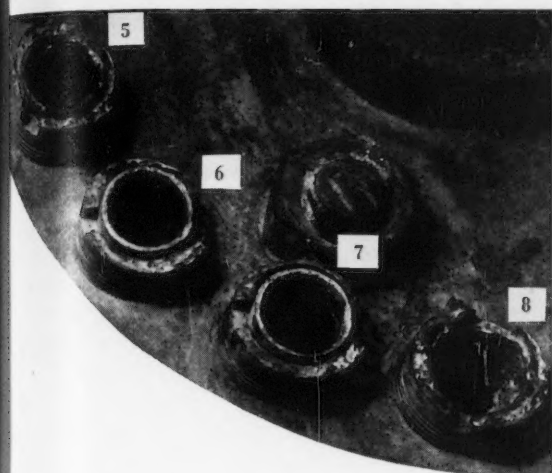


Figure 4—Lower left quadrant. 5. Ambraloy 901 (95-5 aluminum bronze). 6. Special 10% cupro-nickel 754 (High-iron 90-10 cupro-nickel). 7. Eight per cent Phosphor Bronze 353. 8. Plain Admiralty 442.

**Tube No. 7—92-8 Phosphor Bronze  
(Phosphor Bronze 353)**

The inlet end is roughened and the inner wall roughened for a distance of two inches. Remainder of tube in good condition.

**Tube No. 8.—Uninhibited Admiralty  
(Admiralty 442)**

Inlet end corroded away for a distance of  $\frac{1}{4}$  inch. The inner wall is pitted and thinned for a distance of three inches from the inlet. The remainder of the tube is relatively uncorroded. No evidence of dezincification was found in this uninhibited tube but this is not surprising in view of the high velocity of the water.

Figure 5 represents the condition of the inlet ends of the four tubes in the lower right-hand quadrant. These tubes and the tubes in the upper right-hand quadrant are duplicates of the tube in the upper and lower left-hand quadrants, respectively.

**Tube No. 9—Arsenical Admiralty 439**

Inlet end corroded away for a distance of  $\frac{1}{4}$  inch. The inner wall is pitted and thinned for a distance of three inches. Remainder of the tube is relatively uncorroded.

**Tube No. 10—Arsenical Aluminum Brass  
(Ambraloy 927)**

Part of inlet end corroded away for distance of  $\frac{1}{16}$  inch. Inner wall thinned and pitted for a distance of  $1\frac{1}{8}$  inches from inlet. Remainder of tube relatively uncorroded.

**Tube No. 11—70-30 Cupro-Nickel, Low Iron  
(Super-Nickel 701)**

Very slightly roughened at inlet end. Remainder of tube in excellent condition.

**Tube No. 12—70-30 Cupro-Nickel + 0.4% Iron  
(Super-Nickel 702)**

Very slightly roughened at inlet. Remainder of tube in excellent condition.

Figure 6 shows the condition of the inlet ends of the four tubes in the upper right-hand quadrant.

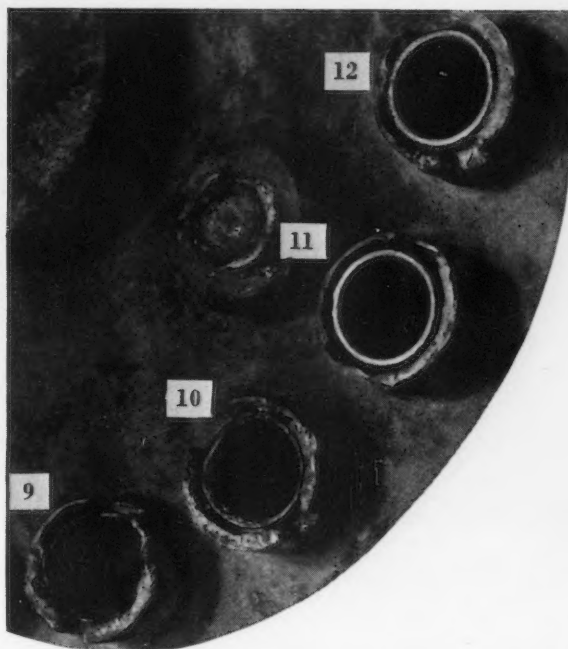


Figure 5—Lower right quadrant. 9. Arsenical Admiralty 439. 10. Ambraloy 927 (aluminum-brass). 11. Super-nickel 701 (Low-iron 70-30 cupro-nickel). 12. Super-nickel 702 (High-iron 70-30 cupro-nickel).

**Tube No. 13—Aluminum Bronze 95-5  
(Ambraloy 901)**

Inlet end thinned and inner wall deeply corroded along a distance of  $1\frac{1}{2}$  inches. Several of these pits extended through wall of tube. Remainder of tube relatively uncorroded.

**Tube No. 14—90-10 Cupro-Nickel + 0.75% Iron  
(Cupro-Nickel 754)**

Slightly roughened on inlet end for distance of about one inch along inner wall. Remainder of tube in excellent condition.

**Tube No. 15—92-8 Phosphor Bronze  
(Phosphor Bronze 353)**

Inlet end roughened for distance of  $1\frac{1}{4}$  inches. Remainder of tube in good condition.

**Tube No. 16—Uninhibited Admiralty  
(Admiralty 442)**

Inlet end corroded away for distance of  $\frac{1}{4}$  inch. Inner wall thinned and pitted for a distance of about  $3\frac{3}{4}$  inches from the inlet. Remainder of tube relatively uncorroded. As in duplicate tube No. 8, no dezincification was found in this tube.

The examination of tubes tested ten months with clean sea water flowing through them at an average velocity of 11.7 feet per second shows that duplicate tubes corroded about equal amounts and that the

Figures 2 through 6 show inlet ends of tubes after ten months' test. Figures 4 and 6 are approximately 20 percent under natural size. Sea water velocity in all cases was 11.7 ft./sec. Detailed analysis of all tube metals may be found in Table I.



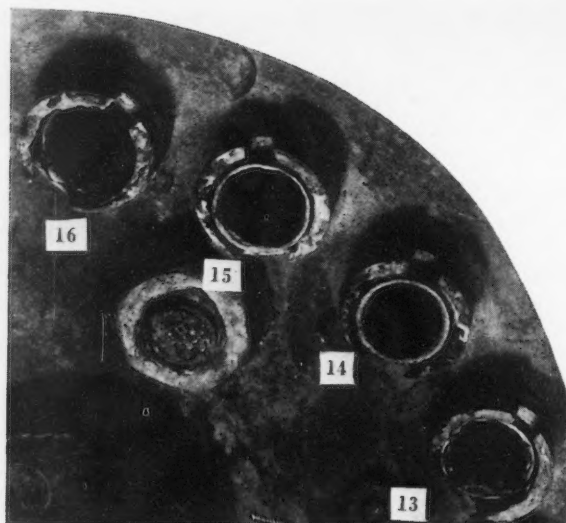


Figure 6—Upper right quadrant. 13, Ambraloy 901 (aluminum bronze). 14, Special 10% cupro-nickel 754 (high-iron 90-10 cupro-nickel). 15, Eight per cent phosphor bronze 353. 16, Plain Admiralty 442.

several alloys can be rated in the following order of decreasing resistance to impingement corrosion:

Super-Nickel 702 (High-iron 70-30 Cupro-Nickel)  
 Super-Nickel 701 (Low-iron 70-30 Cupro-Nickel)  
 Cupro-Nickel 754 (High-iron 90-10 Cupro-Nickel)  
 8% Phosphor Bronze 353  
 Ambraloy 927 (Aluminum Brass)  
 Ambraloy 901 (95-5 Aluminum Bronze)  
 Arsenical Admiralty 439  
 Uninhibited Admiralty 442

The test indicated only a slight difference in corrosion resistance between the 70-30 cupro-nickel with and without iron.

The 92-8 phosphor bronze is not a standard condenser-tube alloy but the results in this test are interesting in showing that this alloy has good resistance to sea water corrosion.

Aluminum bronze, Ambraloy 901, offered mediocre resistance to impingement corrosion in this test. This result confirms the results of tests made in the laboratory. Service tests in power plant condensers in the New York area indicate that aluminum bronze

may be superior to aluminum brass in resisting sea water corrosion, especially in water carrying some pollution and at lower velocities.

### Summary

The tests reported were designed to determine relative resistance to corrosion, particularly by impingement attack, of a series of condenser tube alloys under relatively extreme conditions of service. The velocity of water flow of 11.7 feet per second is appreciably greater than is generally recognized or considered suitable for most condenser or heat exchanger service with standard alloys such as Admiralty.

The results show the marked superiority of the cupro-nickel alloys containing iron in resisting the rather extreme conditions of test. The effect of only 0.75 percent of iron in the 10 percent cupro-nickel alloy is particularly significant. This new alloy is also shown to be superior to the 8 percent tin bronze.

The results confirm laboratory test data in showing the marked benefit to be obtained in the addition of iron to cupro-nickel to improve its corrosion resistance, particularly under conditions of impingement attack.

This new condenser tube alloy\* of nominal composition 90 percent copper, 10 percent nickel with the addition of about 0.75 percent iron, should find extensive use because of lower cost than the standard 70-30 cupro-nickel of higher nickel content. Its lower nickel content also may be of strategic importance.

### Acknowledgement

The cooperation of Mr. F. L. LaQue, of The International Nickel Company, Inc., in permitting the use of test facilities at their Kure Beach Station and of Mr. H. T. Paterson in supervising the test at that station are gratefully acknowledged.

### References

1. A. W. Tracy and R. L. Hungerford, "The Effect of the Iron Content of Cupro-Nickels on its Corrosion Resistance in 'Sea Water'," *Proc. ASTM*, **45**, 591 (1945).

\* Patented.

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# Practical Corrosion Control

## On Gas Transmission Lines\*

By G. R. OLSON and H. V. BEEZLEY

**C**ONTROL OF corrosion on underground metallic structures presents a unique problem in that a solution is always arrived at regardless of what efforts are made toward that end. If no planned program is carried out to control corrosion on gas transmission lines, replacement of pipe eventually becomes necessary, which seems to solve the problem until further replacements are required. This is the expensive solution, but a solution that is inevitable if a complacent attitude is adopted toward this problem.

No progressive operator is content to let the corrosion problem solve itself. He realizes that although there are several possible solutions, good operation requires a careful study of each if the most economical and practical program is to be selected to bring corrosion under control.

Regardless of what is done, corrosion costs money. Corrosion may be eliminated entirely by a suitable means of control, but the cost of applying this control is directly chargeable to corrosion. The best that can be expected is a reduction in the overall corrosion cost by careful study and practical application of proved methods of control.

### Cathodic Protection Use Increases

The most common means of corrosion protection are coatings of various kinds, cathodic protection, and extra pipe wall thickness. The use of cathodic protection either alone or in combination with one or more other methods has increased enormously during the past 10 or 15 years, while the trend has been toward thinner pipe walls. This increased use of cathodic protection is, of course, the result of the fact its effectiveness has been well demonstrated in a practical way over long periods by many applications to pipe line systems.

To take a special example,<sup>1</sup> in January, 1941, cathodic protection was installed on a 20.9-mile section of 8-inch bare line. The condition

of this section of line was such that replacement would have been necessary if corrosion were not brought under control immediately. During the 12 months previous to the effective date of this installation, 525 corrosion leaks were repaired as compared with 105 leaks for the 12 months following, a reduction of 5 to 1. In June, 1943, the protection was extended 9.4 miles, making a total of 30.3 miles of 8-inch bare pipe under cathodic protection.

Operating personnel now are satisfied this installation has proved its value and that this section of line can be maintained in economical operation indefinitely with the help of cathodic protection. It is estimated that total cash savings to date on this 8-inch line amounts to more than \$90,000 compared with pipe replacements which otherwise would have been necessary. Even better savings can be realized on present day installations because the cost of pipe replacements has increased more in past years than the cost of cathodic protection. United Gas Pipe Line Company now has over 5,000 miles of 3-inch equiva-



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lent pipe under cathodic protection, and a larger program of corrosion control is anticipated for the future.

Cathodic protection has several distinct advantages over other methods of corrosion control. It may be applied at any time during the life of the pipe; it may be applied only to known corrosive sections as the need for protection appears; and, after installation, the degree of protection may be altered to accommodate any change in conditions that may occur. The flexibility of cathodic protection might seem to favor delaying its application as long as possible. However, a consideration of all practical factors related to corrosion control will show that its early application is justifiable in a large number of cases.

Generally speaking, it is United Gas Pipe Line Company's policy to install cathodic protection on all new lines laid, either during construction or as soon thereafter as possible. It is a well-known fact that no coating as installed will provide perfect insulation between the pipe and the soil, and corrosion may be expected to take place at holidays or other weak places in the coating where moisture is permitted to enter. The corrosion rate usually will be greatly accelerated in these weak spots because the tendency to corrode will be concentrated in very small areas. This phenomenon sometimes is noted on short replacement where new, well-coated pipe is welded in with old, poorly-coated or bare pipe instead of being tied in with insulating couplings. In such cases, leaks in the new pipe frequently occur within a short time after the pipe is laid. This illustrates the fact corrosion usually is accelerated at the weak spots on a well-coated line if the tendency to corrode is present. Since any long pipe line passes through various types of soils under a number of conditions which cause differences in electrical potential along the pipe, it follows that the corrosion rate will be accelerated at some of the holidays on any newly coated pipe line.

#### Current Required Is Small on Well-Coated Pipe Lines

On new well-coated pipe, properly inspected, and handled carefully during construction, the total area of metal exposed by holidays will be very small, and the amount of current required for cathodic protection will be almost negligible. Since cathodic protection costs usually are proportional to current requirements, the cost of applying cathodic protection to a well-coated line frequently will be less than 2 percent of the cost of the coating. Therefore, if an expensive coating is applied to a pipe line on the assumption that corrosion is going to occur, it would seem like good business to spend an additional 2 percent to obtain the equivalent of a practically perfect coating.

In view of past developments and present day knowledge, the engineering problems involved in applying cathodic protection to well-coated lines have become relatively simple. However, some operators have many lines which were installed years ago when good pipe coatings were not available, or, for

some reason or other, the pipe was laid bare. Many sections of such lines undoubtedly have become so seriously corroded that large replacement expense is imminent if corrosion is not brought under control in the immediate future. Application of cathodic protection to such bare lines presents an entirely different problem. Here the current requirements and cost involved are increased many fold. Such jobs require considerable engineering and careful study of many factors, the most important of which are:

1. Cost of leak repairs
2. Cost of reconditioning and replacements
3. Gas lost through leakage
4. Damages
5. Loss of goodwill
6. Loss of revenue
7. Fixed charges on capital expenditures for cathodic protection and pipe replacements
8. Cathodic protection operation and maintenance costs

#### Cost Cannot Always Be Determined Accurately

It is obvious the cost of each of these items cannot always be determined accurately. However, an evaluation of such intangible items as goodwill and possible damage claims due to hazardous conditions can be made by experienced operating personnel. The choice between installing cathodic protection on an existing line and operating the line without protection should be made only after a careful consideration of the probable results even though some of these results may not be predictable to the extent that an exact evaluation can be made in terms of dollars and cents.

Local conditions introduce many variables, but on United Gas Pipe Line Company's transmission system costs of applying cathodic protection to bare pipe lines average about \$2,000 per mile for 16-inch pipe. Annual operating costs, including the cost of electric energy run about \$200 per mile. Present day costs on pipe replacements are estimated at about \$22,000 per mile of 16-inch line. This indicates that, with cathodic protection as an alternative to major replacements on a 16-inch bare gas line, a cash expenditure of \$20,000 per mile can be saved by assuming an annual operation and maintenance cost of about \$200 per mile.

The application of cathodic protection may seem complicated at times. Actually the fundamental principles are simple. The corrosion of underground metallic structures always is accompanied by a discharge of electric current at the corroding point. To prevent such corrosion, it is necessary to stop the discharge of current to the soil from all points on the metal surface. Cathodic protection achieves this end by forcibly causing a current to flow in a direction that opposes the discharge of current from the metal.

#### Application Requires Skill and Experience

Although the fundamentals of cathodic protection are simple, its application in such a way as to achieve maximum effectiveness at a minimum cost, requires technical training, skill, and sound judgment acquired only through experience. In proceeding to apply cathodic protection to a pipe line, the corrosion engineer must 1) determine the amount of op-



posing current necessary to protect the metal, 2) select equipment to supply this current, 3) choose locations for the equipment that will distribute the current in such a way as to obtain maximum effectiveness, and 4) prepare designs which will give most economical results.

It is emphasized that the first step in the application of cathodic protection to a pipe line is to determine the current required to protect the section of line under consideration. It is fallacious to say that a definite number of galvanic anodes, rectifiers, or any other type of equipment will protect a given section of pipe unless current requirements first have been determined and field tests have been made to determine soil conditions in the immediate vicinity of the pipe line. The determination of current requirements on existing lines may be made by field tests, by an estimate based on experience with other lines on the same right-of-way, or by an estimate based on experience at other locations where similar conditions exist. The condition of the pipe coating must be known in all cases.

In selecting a current source, prime consideration should be given to dependability of the equipment. It has been found that in order to be effective, cathodic protection must be applied continuously or as nearly so as possible. In no case should the operating time of a cathodic protection installation fall below 90 percent each month, and the nearer this figure approaches 100 percent, the more satisfactory the results will be. Cathodic protection units that do not remain in operation practically continuously will not do the job they are intended to do and, consequently, will quickly become a major liability instead of an asset.

#### Common Current Sources Listed

As a current source, the following equipment is used most commonly:

1. Rectifiers
2. Galvanic anodes
3. Gas engine generators
4. Wind-driven generators

Of this group, rectifiers, which convert purchased alternating current energy into direct current, probably are most commonly used where relatively large amounts of current are required. The dependability of purchased power is well established, and a rectifier installation may be expected to remain in operation practically continuously. If reasonable diligence is exercised by personnel in charge of maintenance, the operating time of a rectifier will seldom fall below 95 percent.

For protecting large diameter bare lines, a system<sup>1</sup> has been developed consisting of a 2-conductor power line built along the pipe line right-of-way with 5 to 10 small rectifier units per mile installed to furnish a well-distributed protecting current. Rectifier design is such that extreme flexibility is provided in that the capacity of any unit can be changed easily by adding, removing, or changing rectifier stacks. United Gas Pipe Line Company has used this type of installation for a number of years and found it to be very satisfactory. It now has over 1,000 rectifier units being served by power lines from 1/2-mile

to 30 miles in length along the pipe line right-of-way.

Cost of an installation of this type will vary from about \$1,800 per mile to \$2,200 per mile. Although this may seem high, it must be remembered that an installation of this type would be used only for protecting bare or poorly coated pipe where current requirements are large. Under such conditions, this type of installation will furnish current at the lowest cost per ampere. The total annual cost ranges from \$5.25 to \$7.75 per ampere year, including cost of operation and maintenance, cost of electric energy and estimated fixed charges on the capital invested.<sup>2</sup>

Where a very short section of pipe is to be protected or on lines having a coating in even fair condition, single rectifier units may be used provided purchased power is available at suitable locations. With an installation of this type, excessive current must be supplied near the unit in order to obtain a satisfactory spread of protection, and the installation as a whole is not as efficient as a group of multiple rectifier units. However, this is frequently the most economical type of installation and its use is common.

#### Galvanic Anodes Are Dependable

Where relatively small amounts of current are required, galvanic anodes furnish a dependable and economical source of current. Although the cost of current per ampere year will, in most cases, be greater than for rectifiers, local conditions frequently will favor this type of installation. The most commonly used metals for this purpose are magnesium and zinc. Some experimental aluminum installations are in service at present, but practical development of this metal for use as galvanic anodes has been delayed because of scarcity of this material.

In comparing magnesium and zinc, experience has shown that there is a place for each in the application of cathodic protection. In all soils except those of very low resistivity, magnesium usually will be favored over zinc because of its greater driving potential. Zinc has the higher anode efficiency, but its use on long pipe lines is somewhat limited by its relatively low driving potential. However, in soils of low resistivity the potential of zinc is sufficient to give a satisfactory current output and its use would be favored in such cases. Because of right-of-way requirements, soil conditions or other local factors, galvanic anodes usually are installed in banks of 5, 10 or more.

#### Engine-Driven Generators Used

At locations where large amounts of current are required and purchased power is not available, gas engine driven generators may be used. This source of current is not as dependable as purchased power. In order to obtain satisfactory service from gas engine generators, a well organized maintenance program must be set up specifically for this purpose, and close check on the operation of the units must be kept to see that continuity of operation is maintained. If this is done, results will be quite satisfactory.

Wind-driven generators will not supply the neces-

sary large amounts of current continuously to provide protection to a large diameter bare pipe line. These units have been used with some success, however, to provide protection to short sections of line in locations where the wind blows very nearly continuously. Recently galvanic anodes have been used in conjunction with wind-driven generators. Along the same section of line being protected by the windmills, a relatively small number of galvanic anodes are installed to provide a continuous flow of current during periods of calm when the wind generators do not operate. Because of changes in pipe potential, galvanic anodes will increase their output automatically as the windmill slows down or stops.

### Method of Selecting a Current Source

To illustrate the method of selecting equipment for a current source, consider the hypothetical case of a bare 12-inch line 10 miles long passing through highly corrosive soil. It is estimated that 50 amperes per mile of pipe will be required to provide adequate protection.

First, consider the installation of magnesium anodes. If soil conditions are suitable, 0.1 ampere can be obtained from one 20-pound magnesium anode, and at this output, each anode will have a life of 10 to 12 years. Five hundred anodes per mile will be required. Small magnesium anodes cost about 50 to 60 cents per pound installed, therefore the total installation cost for 10 miles of protection will be \$50,000 to \$60,000—say \$55,000. Then with an assumed interest rate of 4 percent on the initial expenditure, the total annual cost for protecting 10 miles of pipe will be as follows:

Interest at 4% on \$55,000	\$2,200.00
Depreciation at 10%	5,500.00
Operation and Maintenance	100.00
Total annual cost	\$7,800.00
Annual cost per mile	\$ 780.00
Annual cost per amp.	\$ 15.60

If purchased power is available anywhere near this section of line, a multiple rectifier installation with a power line built along the pipe line right-of-way may be considered. Current requirements using this type of installation will be only slightly higher than with galvanic anodes because the current will be well distributed along the pipe by the large number of small units. To supply the required current over the entire line, it is estimated that the alternating current power requirements will be 5.5 kilowatts, or the total energy required per year will be 48,180 kilowatt-hours. The estimated annual cost of protection then will be as follows:

Installation cost 10 miles at \$2,000/mile	\$20,000
Fixed charges on \$20,000 at 12½%	2,500
Electric energy 48,180 Kws. at .02	964
Operation and Maintenance, 10 miles at \$40 per mile	400
Total annual cost	\$ 3,864
Annual cost per mile	\$ 386
Annual cost per amp.	\$ 7.76

Thus it is seen that the most economical protection could be obtained from the rectifier installation. There will be an additional advantage to this

type of protection in that more flexibility is provided which will permit changes in current outputs to accommodate seasonal changes in soil conditions. Also, as it becomes apparent that additional current is needed at specific locations, the necessary changes can be made easily to provide more effective protection.

Only these two sources were considered in this case because, as has been previously stated, dependability of the current source is of primary importance and these two types of installation provide the maximum in dependability. If purchased power is not available near this section of line, some other equipment, such as gas engine generators, should be considered as a source for the large amount of current required for protection.

### Example of Small Current Demand

Consider a case where only a small amount of current is required, such as a 4-inch line, five miles long with a fairly good coating. It is estimated that 1.0 ampere per mile will protect this line, or a total of five amperes will be required if the current is well distributed. Assuming electric power is available at the proper location, the choice in this case would be between galvanic anodes and a single rectifier unit.

If a rectifier is installed, its capacity should be 8 to 10 amperes in order that the minimum current density of 1.0 ampere per mile of pipe will be assured at all points on the line. Assuming an installation cost for the rectifier of \$400, power requirements at 100 watts, electric energy cost of 4 cents per kilowatt-hour, and a cost for operation and maintenance of \$25 per year, the estimated annual cost of protection would be as follows:

Fixed charges, \$400 at 12½%	\$ 50
Electric energy 876 kws at 4 cents	35
Operation and maintenance	25
Total annual cost	\$110

Only 50 magnesium anodes would be required if each anode furnished 0.1 ampere, since the current would be well distributed. With an installation cost of \$11.00 each and a ten year life for the anodes, the annual cost for protection would be as follows:

Depreciation at 10% of \$550.00	\$55
4% on initial expenditure	22
Operation and maintenance	10
Total annual cost	\$87

It is evident galvanic anodes would be preferred for this installation.

These examples have been given to illustrate the method of selecting a current source for cathodic protection. It is not meant to imply that galvanic anodes should be used on all 4-inch lines, or that on all bare 12-inch lines, multiple rectifier units should be used. It is emphasized that each proposed installation is a problem in itself, and the selection of equipment should be based on a consideration of all known factors which will include soil resistivity, coating resistance, availability of right-of-way, investment operation and maintenance costs and dependability of equipment.

### Insulating Couplings Are Important

While cathodic protection current sources are being discussed, it might be well to mention another very important tool in corrosion control. The insulating coupling or flange is essential to the successful application of cathodic protection.<sup>3</sup> If cathodic protection is to be entirely effective, the section under protection must be isolated electrically from all other structures. Sections of transmission lines may be isolated from the rest of the line by installing insulating couplings at the limits of the section to be protected, or flanges on existing valves may be insulated if the valves are suitably located. All tap lines in the protected section should be insulated. Inexpensive insulating fittings are available for isolating these small lines from the main line.

For several years now, it has been standard practice with United Gas Pipe Line Company to electrically insulate each section of new lines built. Usually this can be accomplished at a very small cost by insulating flanges on valves that are installed for operating purposes. In a few cases, it is necessary to install special insulated flange joints. This practice makes it easier to measure coating resistance from time to time and to apply cathodic protection to any section of the pipe line system as demand is made by local conditions or as time permits.

If the magnitude of the corrosion problem seems to involve too many complications for applying cathodic protection to any large system, it is suggested that a program of corrosion control might be started by electrically isolating one or more of the worst sections to work on initially. As corrosion is effectively checked in this pipe, other sections might be isolated and the program of corrosion control expanded further. In this manner, effective results

could be shown with small resources which in turn would encourage the development of a large program for corrosion control.

### Sound Engineering and Efficient Operation Essential

Cathodic protection has been proved to be an economical and effective means of corrosion control provided it is applied in accordance with sound engineering principles and is efficiently operated and maintained. The savings to be effected by its application are as follows:

1. Increase in life of the pipe
2. Savings in leak repair costs
3. Savings of gas lost through leakage
4. Fewer damage claims
5. Goodwill accrued from the assurance of dependable service to customers by maintaining the pipe in good condition.

An adequate staff of corrosion engineers will be an asset to any pipe line company, and full use should be made of the abilities of such engineers as are available. A well planned program of corrosion control will be a substantial contribution to the efficient and economical operation of gas transmission lines.

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## DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in CORROSION, or who wish to register differences of opinion with respect to any articles are urged to send such discussions to Dr. F. N. Alquist, Chairman, NACE Editorial Review Committee, Organic Research Laboratories, 20A Building, Dow Chemical Co., Midland, Mich. Doctor Alquist will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make CORROSION more valuable to the membership.



# The Pulse Polarizer In Corrosion Technology\*

By DR. HUGH J. McDONALD\* and GLENN A. MARSH\*\*

THE RATE at which a corrosion reaction proceeds is determined by a number of factors which may act together or independently. From thermodynamic data,<sup>1,2</sup> when available, it sometimes is feasible to calculate whether a corrosion reaction is possible, but unfortunately very little about the actual rate of reaction can be so determined. The slow steps in ion discharge, diffusion effects, and other possible polarization factors must be investigated before quantitative predictions of corrosion rates can be made.

Polarization may be defined as the production of counter potentials when the chemical energy of a cell is converted to electrical energy. The electromotive force may arise from products formed during, or by concentration changes resulting from, passage of current through the cell. The principal controlling factors in polarization include the limited solubility of a metal in a solution, the rate of proton discharge and hydrogen liberation, and diffusion of corrodant to and products away from the corroding surface. In acidic solutions without a depolarizer present, the hydrogen liberation usually exerts control over the dissolution rate; for this reason the corrosion of metals in acidic media is generally under cathodic control.

In general, if other possible controlling factors are kept constant, the greater the polarization, the lower the corrosion rate will be. It would seem possible, therefore, that if the extent of polarization of a metal in a solution were determined under reproducible experimental conditions, it might serve as an indirect measure of the corrosiveness of the medium towards that particular metal.

## The Pulse Polarizer

The instrument known as the Pulse Polarizer,<sup>3,4,5</sup> shown schematically in Figure 1, and consisting essentially of a high-voltage DC source, a pulse discharge mechanism, sensitive polarization detector and a high-speed strip-chart recorder, provides a convenient method for studying polarization. A high-

voltage regulated power supply is used to charge an electrolytic condenser (capacity 125 microfarads) to 310 volts. The condenser is then discharged through a cell made up of two small, cleaned and degreased samples of metal immersed in about 30 cc of the corroding liquid. One of the two electrodes is suddenly made extremely cathodic, the other extremely anodic as the condenser discharges. With ordinary solution resistances, and neglecting any increase in resistance arising from polarization products, the time constant for this system is about one millisecond, i.e., 63 percent of the charge on the condenser will be dissipated during this time. With 0.05-inch iron wire electrodes described later, the average current density is about 27 amperes per square centimeter over this same time interval.

The potential between the electrode under study, and a standard 1 normal calomel half-cell, is applied to a single stage DC amplifier with variable gain, which allows the use of the recording potentiometer over an extended range of potentials, both positive and negative. A compensating potential enables the operator to set the recorder to zero and thus feed only the variations in current into the recorder. At maximum sensitivity, polarization potentials of about 5 millivolts can be reproduced.

In operation, the chart indicator is brought to the center of the chart with the compensating potential. The pulse of electricity is then discharged by means of a high capacity relay. The inertia of the recorder is such that the pen, traveling at 10 cm per second, cannot follow the rapid IR drop which disappears in a few milliseconds. This circumstance permits the influence of the solution resistance for all reasonably good electrolytes to be neglected. The curves obtained generally show a sharp peak of from a few millivolts to 0.5 volts or more in the anodic or cathodic direction, followed by a return in from 1 to 10 seconds to the normal or equilibrium potential. When samples of the same size are cut from the same piece of metal, and when the same solution is used, the curves produced on different days are identical in every detail.

Metals which polarize rapidly do not, of course, corrode as fast as metals which polarize hardly at all. Hence, the magnitude of the voltage changes gives a direct indication of the corrosion behavior of the metal in the particular solution being used. It is significant that minute changes in composition show up as detectable influences on corrosion rate.

## Applications of the Pulse Polarizer In Qualitative Corrosion Analyses

The field of investigation may be divided into two parts: the application of the instrument in "qualitative" and in "quantitative" analyses of various corroding systems. The qualitative applications will be described first.

The electrodes used for inhibitor evaluation, effects

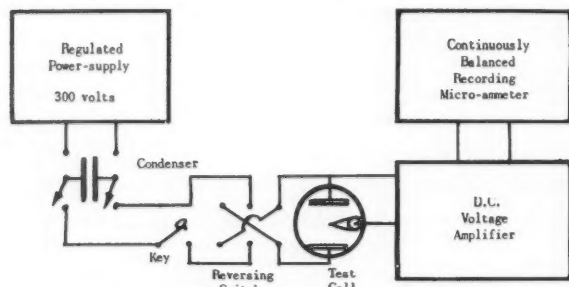


Figure 1. Schematic diagram of the Pulse Polarizer.

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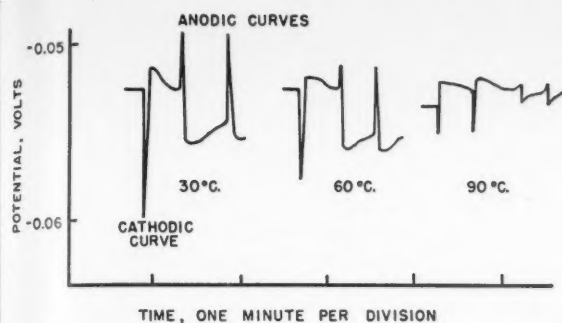


Figure 2. Effect of temperature on the corrosion of steel in 1 N sulfuric acid.

of temperature, and of pH were sections of commercial mild steel wire, 6 cm in length, 0.05 in diameter. The wire was annealed. All the electrodes were given the same cleaning treatment and a fresh electrode was used in each trial with a new medium. All were immersed to a depth of 2 cm to obtain a uniform current density. The cleaning procedure consisted of degreasing the wires, letting them stand in dilute sulfuric acid, and then rinsing them in tap and distilled water. From the experimental work, the effects of the following variable factors, which play an important role in corrosion, were determined.

#### Effect of Temperature On the Corrosiveness of a Medium

The series of curves in Figure 2 show the height of the cathodic polarization at different temperatures. In all cases, the shorter the height of the curve and the smaller the area underneath it (that is, the quicker the return to initial potential), the greater the corrosiveness of the medium. A possible conflict in terms is presented by the pulse polarizer curves, for as the metal is subjected to a cathodic pulse, electrons are supplied to it, and as a result, the potential changes in the anodic (negative) direction. A cathodic pulse, as used in this paper, therefore may be defined as one which supplies electrons to the metal.

It is evident that an increase in temperature reduces both the height and width of the curves. Since concentration polarization is reduced by increasing temperature, it may be concluded that the size of the curve is a measure of the extent of polarization. Consequently, the corrosion rate will, in general, bear an inverse relationship to the size of the curves, since polarization determines the limiting corrosion rate in most systems. The height of the curve may be taken as a measure of the extent of polarization reached at the highest density. The width of the curves, or the time to return to the previous potential value, may be taken as a measure of the rate at which polarization effects are dissipated in a given system. From the steady diminution of the size of the curves and the fact that there is no residual or permanent polarization, one may conclude that concentration effects due to slow diffusion are the only important polarizing factors present.

#### Effects of pH or Acid Concentration on Corrosion

Figure 3 shows the change of the cathodic polar-

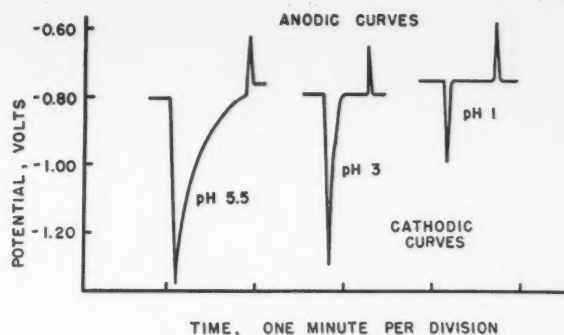


Figure 3. Effect of pH on the corrosion of steel in 1 N KCl (pH varied with HCl); Temperature, 20° C.

ization curves for steel in 1 N KCl (1 normal potassium chloride), with varying pH.

It is evident that cathodic polarization is influenced more markedly than anodic polarization by the change in pH. The size of the cathodic curve diminishes steadily with lowering pH while the anodic curve is not appreciably changed. Hydrogen evolution was quite noticeable on standing at a pH of 1. Upon cathodic discharge the concentration of hydrogen ion in the solution at the surface of the electrode is lowered sharply as hydrogen gas is formed. As a result, the potential changes and does not return to the original value until the initial hydrogen ion concentration is restored. It can be seen from the sample curves reproduced in Figure 3 that this replacement of hydrogen ion takes place more rapidly in solutions of low pH. The width of the polarization curves is a measure of the time for this diffusion process to take place. In the case of neutral or basic solutions, the diffusion process will consist of the dissipation of hydroxyl ions. A large increase in the width of the cathodic polarization curves is thereby to be expected. This prediction was borne out by studying the behavior of the 1 N KCl to which NaOH (sodium hydroxide) solution was added to make the new solution .0001 N, .001 and .01 N respectively in NaOH. The effect on the anodic curves was still small. The cathodic curves were widened markedly by the increase in hydroxyl ion concentration; a residual polarization was evident indicating that the nature of the surface had changed, perhaps because of a layer of adsorbed hydrogen. The anodic curve for the .01 N NaOH solution was noticeably larger than the others. In this case, a temporary layer of mixed iron hydroxides may be responsible.

#### Effectiveness of Inhibitors

All inhibitors may be placed in one of three classes.<sup>6</sup> 1. Surface conversion inhibitors. 2. Adsorption inhibitors. 3. Diffusion inhibitors. The first class includes those materials which can react chemically with the metal and whose reaction product is relatively impermeable to the corrosion medium. Heavy metal salts such as those of antimony and arsenic are included since they also change the nature of the metal surface by chemical reaction. Other examples are nitrites, chromates and phosphates. It is evident that the protection afforded by surface conversion agents will increase with time as the protective layer is built up. It is likely that adsorption is the first step in protection with sodium chromate. The protection does not stop there, however, as in the case of the

next class but continues with the formation of a protective layer by chemical reaction. This fact serves to distinguish this class of inhibitor from the remaining two.

The next class consists of the adsorption inhibitors, including all the important polar compound types of organic materials. These substances do not react chemically with the metal surface but form an adsorbed layer which prevents electrochemical action. This adsorption may be specific, beginning initially at the anodic or cathodic areas. The end results, however, probably will be complete surface coverage. Ionic conductance, of itself, is not affected by absorption inhibitors but is affected by the materials of class 3 which may be called diffusion inhibitors. The materials, such as gelatin, casein, colloidal substances, etc., are not distinguished for their adsorption but serve to increase the viscosity of the medium and lower the ionic conductance. In this way the internal resistance of a galvanic cell is increased and corrosion is reduced. In general, this class is less effective and less important than classes 1 and 2.

Diffusion inhibitors are distinguished readily by means of the pulse polarizer. It was found experimentally that the potential of an electrode after the pulse of current has passed does not return completely to its original value in the case of adsorption inhibitors. However, in the case of gelatin, which falls under the classification of diffusion inhibitors, the final potential value is always equal to the initial. As might be expected, the time to return to the original value increases with increasing concentration of gelatin. It appears, then, that an electrode is permanently polarized to some extent when an adsorption inhibitor is used, whereas there is no residual polarization observed in the case of diffusion inhibitors.

Figure 4 indicates how the pulse polarizer may be used to evaluate inhibitors. The curves for steel in 1 M  $H_2SO_4$  (molal sulfuric acid) with different amines added show clearly the value of this method. Mercaptobenzothiazole, which gives the largest curve, is well known as an effective inhibitor, for example, in pipelines carrying petroleum products. While the others have been used in various applications, they are not so effective.

The instrument also may be used to evaluate effectiveness of different concentrations of a particular inhibitor.

Table I and Figure 5 show the correlation between weight-loss data reported by Warner,<sup>7</sup> and the pulse polarizer curves, for different concentrations of gelatin in 1 M  $H_2SO_4$ . The systematic changes pro-

duced by an increasing amount of gelatin are evident. It is interesting to note that the anodic and cathodic curves are both affected. Thus, it is not correct to say that gelatin is only a cathodic inhibitor. The anodic effect seems to be equally important. From the nature of the curves, it appears that gelatin is a diffusion inhibitor, whose effectiveness can be traced to its ability to increase concentration polarization. It may be seen that the first addition is the most important in reducing corrosion, in agreement with Warner's observations. Subsequent additions are helpful, though, because the anodic curve definitely is broadened.

Another application of the pulse polarizer was disclosed while attempting to correlate data on the effectiveness of inhibitors for stress corrosion cracking of mild steel with polarization data. Stress corrosion tests had been conducted with two typical cathodic (adsorption type) inhibitors, namely, thiourea and diphenylamine, and with two anodic (surface conversion type) inhibitors, namely, potassium dichromate and benzoylperoxide. Stressed mild steel specimens in a gently boiling, concentrated solution of mixed nitrates were used. The procedure and theory are fully described in a recent monograph.<sup>8</sup> The benzoylperoxide (a saturated solution; ca. 0.05 percent by weight) gave the best performance of the four. The dichromate was ineffective in a 1 percent solution and did not give complete protection even when a 20 percent solution was used. No appreciable protection was afforded by the thiourea or diphenylamine.

Polarization data were obtained with these same solutions at 85° C, using iron wire electrodes of the regular type. The results are not illustrated, except for the benzoylperoxide, but readily may be summarized. All the cathodic curves also were steep but differed in height for the blank, dichromate, thiourea, and diphenylamine. The order of increasing polarization (height of the cathodic curve) was: blank.

TABLE I  
Inhibitor Action of Gelatin, According to Warner<sup>7</sup>

Grams of Gelatin per liter	Relative Corrosion, percent
0.00	100.0
.25	31.5
.75	27.4
1.25	23.8
1.75	23.4

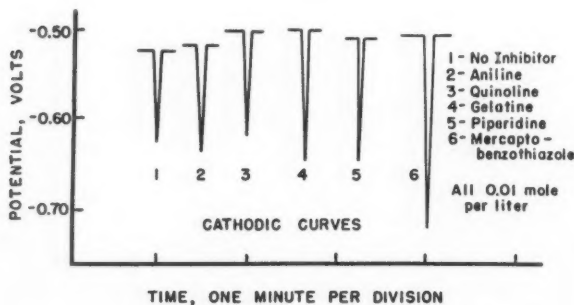


Figure 4. Evaluation of inhibitor effectiveness.

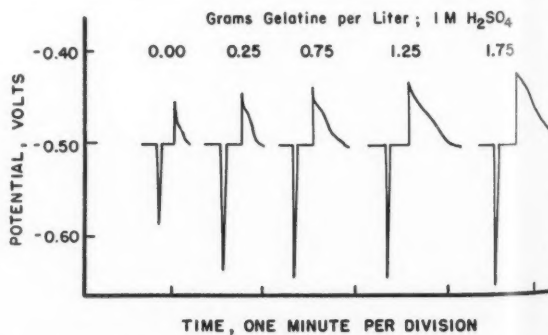


Figure 5. Effectiveness of various concentrations of gelatin in reducing the corrosion of iron.



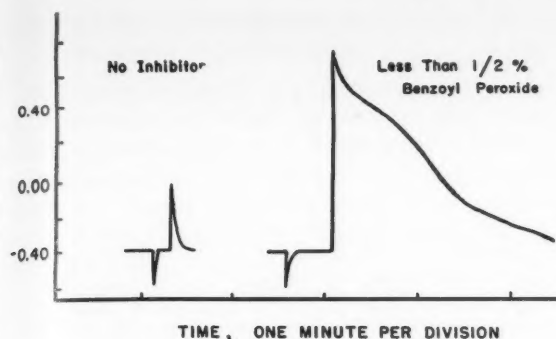


Figure 6. Effect of an anodic inhibitor on the anodic pulse polarization curve for steel in a hot solution of mixed nitrates.

dichromate, thiourea and diprenlyamine. The really striking difference, however, as shown in Figure 6, was in the anodic curve for benzoylperoxide. The maximum height of this curve was about equal to that for diphenylamine but the curve was much wider, indicating much greater polarization. Accordingly, the effectiveness of this material as a stress corrosion inhibitor was completely verified by the curve traced out on the pulse polarizer which indicated that a small amount of benzoylperoxide has a very great effect on increasing the amount of anodic polarization.

#### Influence of the Electrode Material

The two principal factors in polarization behavior are the nature of the medium and of the electrode material. Most of the previous experiments were confined to changes in solution composition. Iron electrodes were used and a fixed electrode area maintained for all the experiments thus far described. In this phase of the work, however, a 1 N KCl solution was used as a standard and different metals were used as electrodes, the electrode area in these trials being 2 sq. cm. Although aluminum, antimony, cadmium, copper, magnesium, tin, zinc and mild steel were studied, only the curves for steel, copper, antimony, and tin are shown in Figure 7. The curves are reproducible for a given area of metal in a given solution. Copper and antimony showed appreciable anodic polarization. It is possible that with copper, some oxygen evolution was obtained in the anodic discharge and a layer of copper oxide formed on the surface. This would account for the large residual polarization obtained with copper. The large anodic curve for antimony may be due to the fact that antimony salts hydrolyze very readily, so that the electrode surface was covered with  $\text{SbOCl}$  or  $\text{Sb}(\text{OH})_3$  upon anodic discharge. In comparing the cathodic curves, it was found that, in general, the size of the curve is proportional to the hydrogen over-voltage of the metal. Thus antimony and tin showed much larger cathodic polarization curves than the other metals except for aluminum. The unusual dip in the curve for tin cannot be explained at present.

It is evident from the pulse polarization data that each metal exhibits a characteristic polarization behavior. In considering corrosion in bimetallic systems, the weight loss will depend on the anodic and

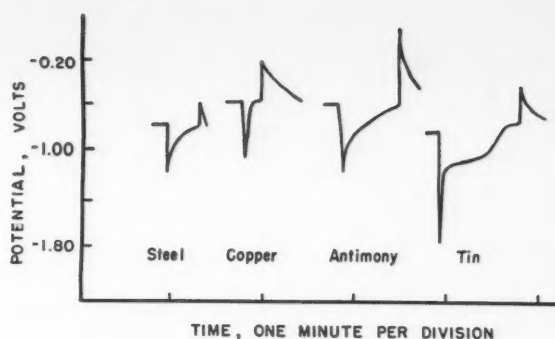


Figure 7. Typical Curves for four different metals in 1 N KCl.

cathodic polarization behavior of both metals. In comparing two metals, if No. 1 has a low anodic polarization and No. 2 has a low cathodic polarization, the corrosion will be considerable if No. 1 is anodic to No. 2. If the electrochemical order is the reverse, then the extent of corrosion will depend on the cathodic polarization of No. 1 and the anodic polarization of No. 2. In this way, the pulse polarization curves obtained for different metals can be used to predict the corrosion behavior of various couples. Such a method is superior to a consideration of potential differences alone.

#### Identification of Alloys

When it was found that the pulse polarization curves for several different metals were distinctive and reproducible, it became apparent that the pulse polarizer might lend itself to the identification of alloys. Figure 8 shows anodic curves for two stainless steels. Both anodic and cathodic differences were observed but the anodic differences were more distinctive and therefore are reproduced here. The steel having a small percentage of molybdenum shows up with a greater anodic curve when run in potassium chloride solution. It is significant, too, that in 1 N  $\text{H}_2\text{SO}_4$  (normal sulfuric acid) solution the larger curve was given by the steel which contained no molybdenum. This result indicates the importance of the medium in differentiating electrode materials. The cathodic curve for stainless steel in  $\text{H}_2\text{SO}_4$  (not illustrated), showed a large permanent polarization. There was no tendency to return completely to the original potential value. This behavior is unlike that of a noble metal such as platinum, where the return was observed to be quite rapid always. Hydrogen adsorption may be responsible for this difference in behavior.

The results obtained from these experiments and from those on other alloys demonstrate the feasibility of using the pulse polarizer in differentiating between alloys of slightly different composition and in identifying alloys in general. A thorough preliminary investigation involving the choice of a standard medium for any particular problem in alloy identification is indicated.

Figure 9 shows how two magnesium alloys may be differentiated. The alloys differed in composition by a few parts per hundred of aluminum. Each pure

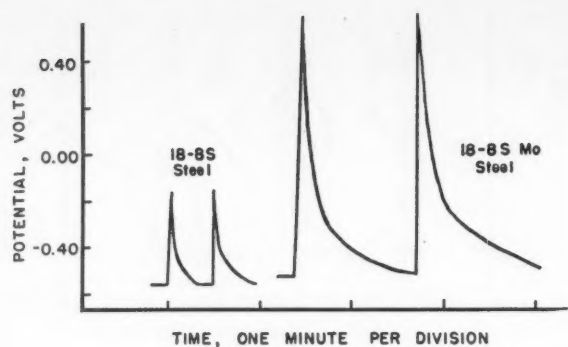


Figure 8. Effect of alloy constituents on the anodic pulse polarization curve for steel in 1 N KCl.

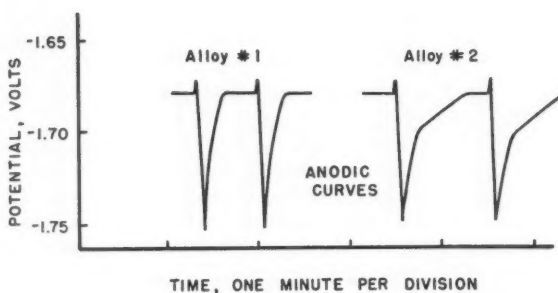


Figure 9. Pulse polarization curves for two magnesium alloys.

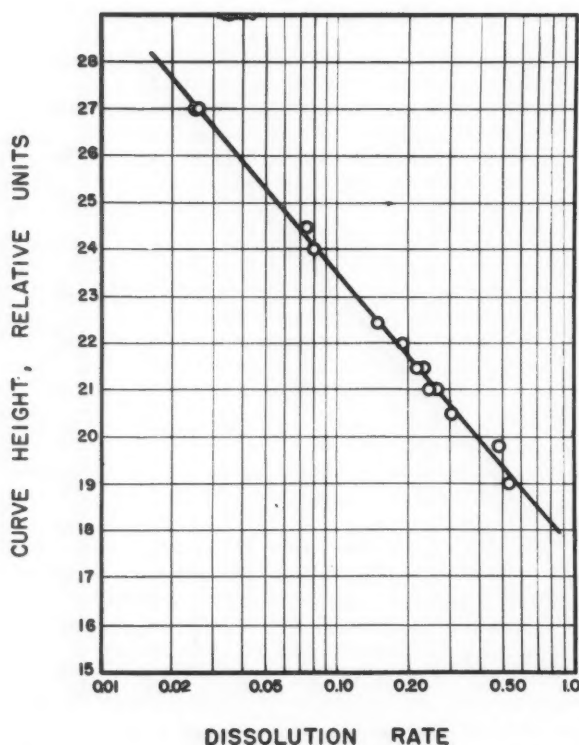


Figure 10. Linear plot obtained when the polarization potentials are plotted against actual corrosion rates.

metal and alloy seems to give a characteristic curve in any given solution.

### Applications of the Pulse Polarizer In Quantitative Corrosion Analyses

To obtain quantitative data on the relationship between dissolution rate and pulse polarization potentials, a series of solutions were prepared, composed of 0.01 molar concentrations of various organic chemicals in an acidic solution. To the solution, originally 50 mol % ethanol and 50 mol % water, sulfuric acid was added to make it 1.0 molar with respect to that acid. The ethanol concentration was desirable in order to effect solubility of the added chemicals. Table II indicates the solution, the average corrosion rate of mild steel, and the polarization potential observed. Most of the added chemicals inhibited corrosion but a few actually accelerated it. The acceleration effect of nitro-compounds can be explained by the fact that they are known to speed up the hydrogen discharge process and if present in sufficient concentration they allow hydrogen ions to be reduced without the formation of hydrogen gas.<sup>9</sup>

The data of Table II were next plotted to give Figure 10. The ordinates of the graph are the chart units which were originally used to compare the heights of the polarization curves. Such heights were converted to polarization potentials by means of the factor "250 chart units equal 1.000 volts." The abscissas have the units of "grams per 6 sq. in. per 40 hours."

The linear plot obtained when the polarization potentials are plotted against actual corrosion rates is evident in Figure 10. Such a plot indicates, at least for the system studied, that the dissolution rate may be quantitatively predicted from polarization data. It must be borne in mind that the system chosen was under cathodic control and that an effort was made to minimize the effects of concentration polarization by rapid work. The solution was exposed to the atmosphere in each case and it is to be assumed that the pressure of dissolved oxygen plays some role in the cathodic process. Since the amount of oxygen and its diffusion rate is small in comparison to the rapid liberation of a large quantity of gas at the cathodic during a pulse, it can reasonably be assumed that the influence of dissolved oxygen on the curves is small or, at least, reproducible.

TABLE II  
Corrosion Rates of Steel in Various Solutions and Pulse Polarization Potentials Observed

Chemical Added	Inches Penetration per Year	Pulse Potential
Nitrobenzene	0.1531	0.0760
1-Nitropropane	0.1380	0.0792
Phenyl chloride	0.0860	0.0820
Blank	0.0756	0.0840
n-Butyl amine	0.0721	0.0840
Phenyl iodide	0.0654	0.0869
Benzene	0.0627	0.0860
n-Butyl chloride	0.0543	0.0884
Benzonitrite	0.0435	0.0900
t-Butyl bromide	0.0231	0.0960
Thiourea	0.0214	0.0980
n-Butyl iodide	0.0074	0.1080
sec-Butyl iodide	0.0072	0.1080

In an effort to postulate a mechanism for the linear relationship, the following line of reasoning was considered:

From each of the most popular theories of hydrogen overvoltage,<sup>10,11,12</sup> the current  $I$  resulting from discharge of hydrogen ions is related to overvoltage  $W$  as

$$I = ae^{\alpha WF/RT} \quad [1]$$

where  $a$  and  $\alpha$  are constants (the latter having the value of 0.5 experimentally),  $F$  is the faraday, and  $RT$  is related to the internal energy of the atom,  $R$  being the gas constant and  $T$  the temperature in degrees Kelvin. For each equivalent of protons discharged, one equivalent of iron must pass over into ferrous ions.

Anodic current  $I_a$  is, however, proportional to the dissolution rate:

$$\frac{dx}{dt} = \frac{I_a M}{nF} \quad [2]$$

where  $dx/dt$  is the rate of dissolution per unit area,  $M$  is the molecular weight of the metal,  $n$  is the valence charge and  $F$  is the faraday.

$$I = I_a = \frac{nF}{M} \frac{dx}{dt} = ae^{\alpha WF/RT} \quad [3]$$

$$\text{or } \log \frac{dx}{dt} = \log \frac{Ma}{nF} + \alpha WF/RT \quad [4]$$

$$W = -\log \frac{Ma}{nF} \cdot \frac{RT}{\alpha F} + \frac{RT}{\alpha F} \log \text{Rate} \quad [5]$$

The equation relating overvoltage to dissolution rate is then

$$W = A' - B' \log \text{Rate}$$

where  $A'$  and  $B'$  are constants. Dissolution rate is a function of the angle of intersection of the hypothetical polarization curves which show polarization of the primitive potentials with current density.<sup>13</sup> Consequently,  $A'$  and  $B'$  may not be theoretically evaluated until further work has been done in the field. For convenience, although only a reasonable approximation,  $W$  may be taken as a linear function of the log of the Rate.

The height,  $h$ , of the pulse polarization curves, although practically proportional to  $W$ , is different in magnitude because of time lag in the recorder. The true overvoltage picture could be obtained with an oscilloscope since the cathode ray has negligible inertia; however, there are certain practical advantages in using a strip chart recorder to record the phenomena.

There is then the approximate relationship

$$h = A - B \log \text{dissolution rate} \quad [6]$$

which apparently holds fairly well for systems under cathodic control.

Another set of data which is useful in checking this relationship is presented in Table III. Here the weight-loss dissolution rates of zinc in methanol-water mixtures 0.01 N in HCl and containing 0.05 M nitromethane are given for stirred solutions.<sup>14</sup> Using pulse polarization data for zinc in similar solutions, the dissolution rates may be predicted by

obtaining the constants  $A$  and  $B$  of equation 6; because the solvent is changing continuously, the constants are different in strong and dilute solutions.

TABLE III  
Dissolution of Rate of Zinc in Various  
Methanol Concentrations  
(All solutions 0.01 N in HCl, 0.05 in CH<sub>3</sub>NO<sub>2</sub>)

CH <sub>3</sub> OH %	Weight-Loss Dissolution Rate (relative)	Rate Predicted from Polarization	h	Constants in Equation 6
0	1.00	1.00 <sup>1</sup>	13.6	A = 13.6
6.5	0.76	0.75	17.8	B = -33.0
13.6	0.64	0.60	21.0	
29.3	0.50	0.50 <sup>1</sup>	23.6	
45.3	0.45	0.50	23.6	
60	0.30	0.39 <sup>1</sup>	22.6	A = 74
72	0.38	0.41	21.5	B = -37.2
86	0.42	0.42	21.4	
100	0.50	0.50 <sup>1</sup>	18.5	

<sup>1</sup>Rates used in obtaining constants.

Earlier in this article, quantitative experiments were described, showing how the pulse polarization curves for steel in sulfuric acid changed with addition of gelatin. On the basis of equation 6, this work was reviewed to see if a quantitative relationship could be obtained. The results are summarized in Table IV.

TABLE IV  
Corrosion Rates of Mild Steel in 1 M H<sub>2</sub>SO<sub>4</sub>  
with Gelatin as Inhibitor

Gelatin g/liter	Relative Corrosive Data	
	Weight Loss (%)	Pulse Polarizer Data
0.00	100.0	100.0 <sup>1</sup>
0.25	31.5	38.0
0.75	27.4	27.0
1.25	23.8	25.0
1.75	23.4	23.4 <sup>1</sup>

<sup>1</sup>Used in obtaining equation (6) for calculation of other values.

It is interesting to note that the corrosion rates predicted from pulse polarization data are in line with similar data obtained from weight-loss experi-

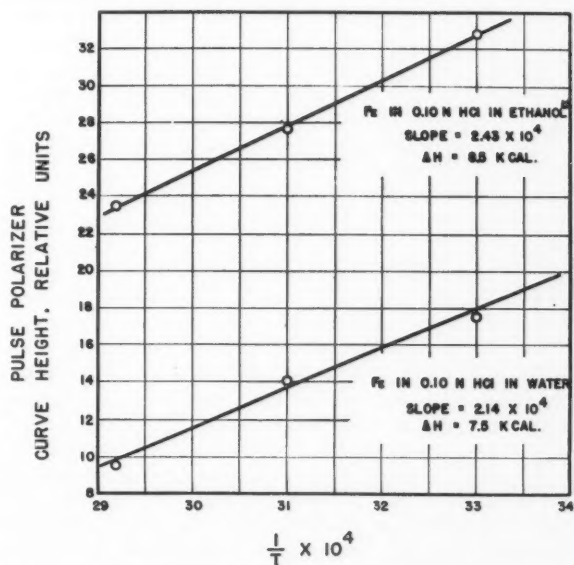


Figure 11. The height of the polarization curves versus the reciprocal of the absolute temperature (degrees Kelvin).



ment. This is true even though gelatin seems to act mainly as a barrier-type or diffusion inhibitor rather than adsorption type.<sup>6</sup> The particular mechanism which enables the polarization to be so affected by such inhibition is not clear. However, subsequent experiments with sucrose and glue, which also are diffusion barriers, revealed that this behavior is general.

Equation 6 relating dissolution rate to polarization measurements implies that energy of activation data also may be obtained from polarization. Ordinarily, energies of activation are obtained from chemical kinetic data by obtaining the rate of a process at several temperatures and plotting the log of the reaction rate constants vs. reciprocal of absolute temperature. The length of polarization curve has been plotted vs.  $1/T$  for several systems. The data for these plots are given in Table V and the plots are given in Figure 11.

TABLE V  
Energy of Activation of Iron in 0.10 N HCl

Solvent	C.	K.	$10^4/T$	Curve Height	$\Delta H_a$ k cal
Water	30	303	33.0	17.6	7.5
	50	323	31.0	14.0	
	70	343	29.2	9.6	
Ethanol	30	303	33.0	32.8	8.5
	50	323	31.0	27.7	
	70	343	29.2	23.5	

The systems studied were iron dissolving in 0.10 N HCl in ethanol and in water. Slopes obtained in these plots have the units

$$\text{Slope} = \frac{h_2 - h_1}{\frac{1}{T_2} - \frac{1}{T_1}} = \frac{B (\log \text{rate}_2 - \log \text{rate}_1)}{\frac{1}{T_2} - \frac{1}{T_1}}$$

The slopes must be divided by the constant B in order to yield the proper dimensions. From equation 5, it may be noted that B is equal to  $RT/F$  multiplied by a constant which depends on the conversion of chart length to potential, and also on the time lag due to recorder inertia. Neglecting the latter dependence, and considering B constant over the narrow temperature range, the value as calculated is 13 chart divisions. (For iron in dilute sulfuric acid, the value of B experimentally is 13.8; other solvents, however, have yielded B from 5.89 to 37.0).

The energies of activation for the systems referred to are calculated to be

$$\Delta H_a = 8.5 \text{ k cal for ethanol}$$

$$\Delta H_a = 7.5 \text{ k cal for water}$$

These values calculated from polarization data are admittedly uncertain but are of the correct order of magnitude when compared with energies of activation obtained by conventional methods. Bowden and Agar,<sup>15</sup> for example, computed  $\Delta H_a$  for the "direct electrode process" of several metals and solutions, and found that it varied from 6.0 to 20.0 kilocalories.

The use of polarization data in calculating corrosion rates has the advantage that, when standardized by weight-loss data, they are more easily and rapidly obtained than are weight-loss data, and yield reproducible results somewhat more free of operational error. The disadvantages are that a complete theoretical treatment is not available yet for cases

where the rate changes with time, i.e., orders other than zero order. Much of the work done thus far (in establishing whatever quantitative relationships may exist), has been necessarily of a preliminary nature.

### Summary

The pulse polarizer is an instrument of many potential uses in the field of corrosion and in electrochemistry in general. In its application to corrosion technology, it has been used to replace conventional weight-loss or hydrogen-evolution tests under certain conditions. It consists essentially of a high-voltage DC source, a pulse discharge mechanism, sensitive polarization detector and a high speed strip-chart recorder. A high voltage condenser is discharged almost instantaneously across a cell made up of a solution containing two electrodes, and the potential of the electrode under study (which may consist of a metal specimen whose corrosion rate in the medium is desired) is measured against a standard reference calomel electrode which also is immersed in the solution. The potential difference existing between these electrodes is detected on an electronic voltmeter circuit, amplified and applied to a high-speed recorder, which traces out the potential of the test electrode as a function of time. The curves are reproducible and distinctive with small changes in conditions.

Applications of the instrument to the study of corrosion inhibitors, to the choice of a metal for use in a particular environment, to alloy identification, and to the choice of an inhibitor for stress corrosion are described. For certain corrosion reactions under cathodic control, data obtained with the pulse polarizer may be used to predict corrosion rates in a quantitative fashion. Quantitative data are secured by first standardizing the pulse polarization chart with curves for several corroding systems for which weight-loss data are available. It has been found that the energy of activation for the dissolution of iron in acid, calculated from the dissolution data, is of the same order of magnitude as the energy calculated in the conventional way.

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# Physical and Corrosion Characteristics of Lead in the Chemical Industry\*

By KEMPTON H. ROLL

A STUDY OF the corrosion characteristics of lead without including its physical characteristics as well would represent only a partial consideration of the role of lead in the chemical industry. From information in the files of the Lead Industries Association, and through the cooperation of its members who represent both producers and consumers of lead, this paper has been prepared in an effort to evaluate the performance of lead and the service it renders to the chemical industry in terms of its physical and its corrosion characteristics. It is important to the lead industry as well as the chemical industry that users and potential users of lead be fully aware of what they can and cannot expect from it.

## Chemical Properties

The broad use of lead as a material for keeping corrosive chemicals under control is natural, since it successfully repels the attack of so many corrosive chemicals. The protection afforded by lead is achieved in most instances by the formation of a thin adherent surface film of oxides or salts which form when the lead is exposed to corrosives. It is this film, serving as a protection to the metal beneath, which gives lead its corrosion resistance.

Lead generally has good resistance to neutral solutions where lead carbonate and possibly oxide are corrosion products, and fair resistance to alkaline solutions in which these are soluble. Experience has shown that lead is commercially resistant to chromic, sulfuric, sulfurous and phosphoric acids; that it is subject to corrosion at somewhat higher rates by hydrochloric and hydrofluoric acids; and that it is susceptible to being strongly corroded by acetic, formic and nitric acids. Also, nitrate salt solutions are moderately corrosive whereas carbonate solutions are not.<sup>1</sup>

## Corrosion Rate Interpretation

It is important in discussing corrosion that a uniform system of designation be used, such as inches penetration per month or year or milligrams per square decimeter per day. But either of these systems can be somewhat misleading in the case of lead because the common tendency is to judge best performance on the basis of the lowest corrosion rate. This method fails to take into consideration the fact that lead used in chemical equipment is normally

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3/16-inch thick or more. Other metals also used in chemical equipment seldom approach the thickness of lead. It can be seen that even in those cases where lead has a higher corrosion rate than another metal or alloy, it still could outlast the other metal in service because of this difference in thickness.

Designating corrosion rate according to weight loss as milligrams per square decimeter per day instead of volume loss as inches penetration per month is also misleading in the case of lead because lead has the highest density of any commonly used corrosion-resistant material. This means that what might appear to be an excessive corrosion rate expressed in weight loss of lead actually could be a very nominal rate of corrosion in terms of volume loss.

When comparisons are being made between various corrosion resistant materials it follows that an understanding and appreciation of the above will lend much to the proper interpretation of corrosion rate data.

## Effect of Concentration

The concentration of a corrosive chemical and its co-influence, temperature, both are important considerations in deciding whether lead can or cannot be recommended for use with the corrosive. Apparent contradictions in leads behavior at different concentrations are best illustrated and in part explained by example. Sulfuric acid and nitric acid are typical examples. It is well known that dilute sulfuric acid forms a film of insoluble sulfates which succeed in passifying the surface of the lead. However, as the concentration of the acid approaches 96 percent, it dissolves this protective film at a more rapid rate, thereby exposing the lead to increased reaction with the acid. For this reason lead may be used safely with any concentration of sulfuric acid as long as it does not exceed 96 percent at room temperature. An example of typical service is shown in Figure 1.<sup>2</sup> The lead linings in the chambers of this acid plant after 47 years of service showed an average loss in thickness of only 1/128-inch or, expressed in inches pene-

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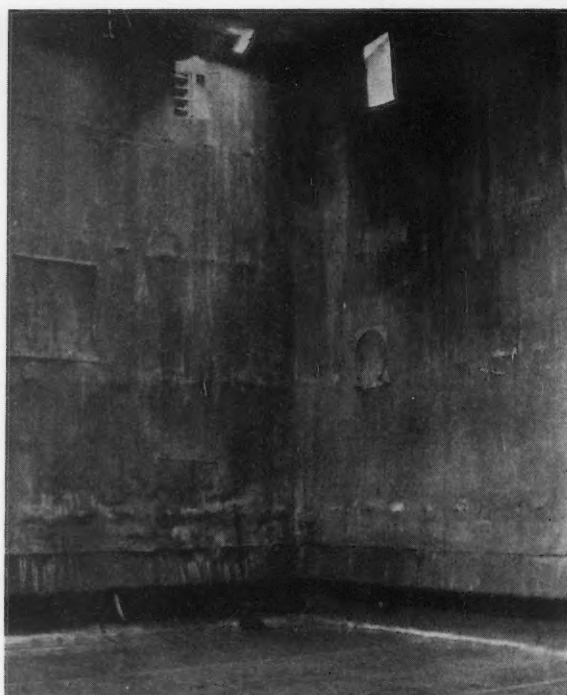


Figure 1. Interior of a lead-lined sulfuric acid chamber originally put into service in 1884. The 6-lb. lead showed an average loss in thickness of only 0.0078 inches. Patches had been applied to only about 15 percent of the area in the intervening years. This equipment was later replaced by more efficient Mills-Packard chambers.

tration per month,  $14 \times 10^{-6}$ . Lead satisfactorily resists hot acid of all strengths up to 85 percent with temperatures up to  $220^{\circ}\text{C}$ . ( $428^{\circ}\text{F}$ ).<sup>3</sup> This case typifies the reaction of lead with most corrosives including chromic acid, sulfurous acid, phosphoric acid (up to 85 percent), and others.

Dilute nitric acid, on the other hand, also reacts with lead to form lead nitrate, but the salt in this case is non-adherent and somewhat soluble in the acid and therefore offers little protection to the metal from further reaction. Concentrated nitric acid in the range of 52 to 70 percent by weight has little effect on lead at room temperature presumably because the solubility of the nitrate decreases with increasing acid concentration. (See Figure 2.) Acetic and hydrofluoric acids and sodium bisulfate parallel nitric acid in their reaction with lead.<sup>3</sup>

#### Effect of Temperature of Corrosive

Since chemical reaction rates are geometrically proportional to temperature, it follows that an increase in the temperature of the corrosive, concentration being maintained constant, almost invariably increases the corrosion rate. The rate of corrosion in inches penetration per month of lead exposed to a mixture of dilute sulfuric acid and sodium chloride at increasing temperature is shown in Figure 3.<sup>1</sup> Regardless of a safe concentration range, it is important before specifying lead for use with a corrosive that the temperature of the corrosive be known and taken into consideration.

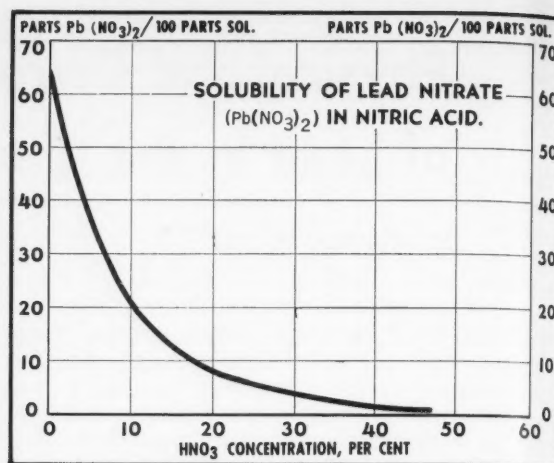


Figure 2. Solubility of lead nitrate ( $\text{Pb}(\text{NO}_3)_2$ ) in nitric acid. Parts of lead nitrate per 100 parts of solution are plotted against nitric acid concentration in percent.

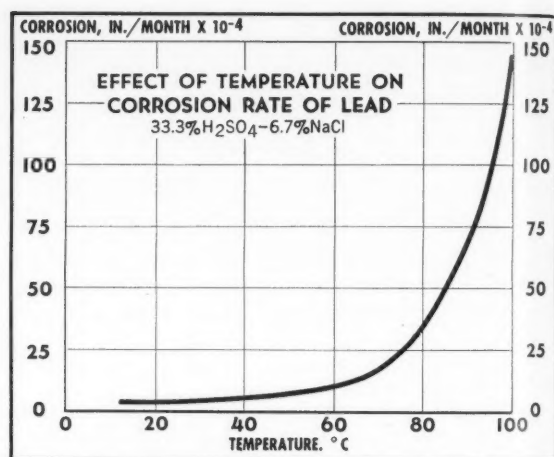


Figure 3. Effect of temperature on the corrosion rate of lead in a solution of 33.3 percent sulfuric acid plus 6.7 percent sodium chloride.

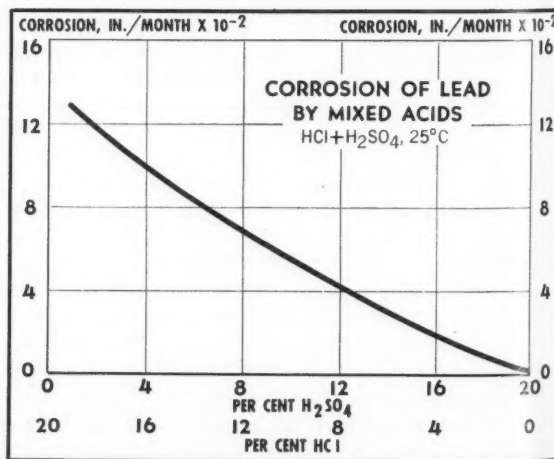


Figure 4. Corrosion of lead by mixed acids, hydrochloric and sulfuric at  $25^{\circ}\text{C}$  varying in concentration from 0 to 20 percent.



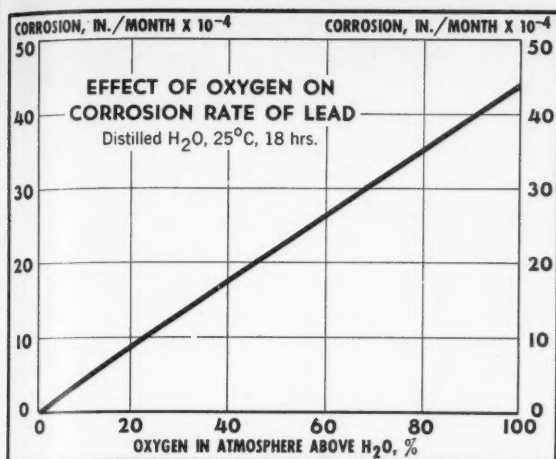


Figure 5. Effect of oxygen in distilled water at 25° C on the corrosion rate of lead. Percentage of oxygen in the atmosphere above the water is plotted against corrosion rate. Specimens were tested for 18 hours.

### Effect of Mixed and Impure Corrosives

As a general rule it may be stated that in mixtures of corrosives the various constituents will react with lead as they would normally in the unmixed state. Figure 4 shows the corrosion of lead by mixed sulfuric and hydrochloric acids.<sup>4</sup> The corrosion rate decreases as the percentage of the sulfuric acid in the mixture increases since lead is more resistant to this acid than it is to hydrochloric.

Corrosives containing comparatively small percentages of other constituents occasionally can be deleterious to lead. Of these, liquids containing dissolved gases, particularly oxygen, are the most important. Figure 5 shows the effect of oxygen on the corrosion of lead submerged in distilled water at room temperature.<sup>5</sup>

Table I illustrates the effect of aeration and agitation on lead in a weak acetic acid solution at room temperature.<sup>1</sup>

Tests were run for a 100-hour period.

TABLE I

Quiet immersion	$8 \times 10^{-4}$ inches/month
Spray	25 " " " "
Aerated	37 " " " "

Tests with phosphoric acid have brought out the fact that impure acid is better resisted by lead than is the pure acid. The impurity in this case is primarily sulfuric acid carried over from the conversion of superphosphate.

In one contact sulfuric acid plant a corrosive liquor at a temperature of 52° C (125° F) saturated with sulfur dioxide and containing in addition 56.5 g. per l. sulfuric acid, 1.9 g. per l. chlorine, and 4.1 g. per l. ferrous iron plus occasional traces of fluorine has been handled in lead equipment with little or no evidence of corrosion for more than ten years.<sup>6</sup>

### Fatigue and Stress Corrosion

Because lead has a relatively high linear coefficient of thermal expansion ( $29 \times 10^{-6}$  per degree C, 17 to 100° C,<sup>3</sup> or approximately three times that of steel) it undergoes considerable movement when subjected to severe cyclic temperature changes. It is this dif-

ferential in expansion rates which largely accounts for the occasional cracking of lead due to buckling. Adequate and proper strapping serves practically to eliminate or minimize this effect. Other factors which occasionally contribute to fatigue conditions include vibration such as that transmitted by nearby machinery, stirring equipment, etc. and strain induced as a rule by inadequate support of hanging sheet lead.

Fracturing caused by repeated bending is hastened by simultaneous exposure to corrosive conditions, thus resulting in a form of stress corrosion. The normal fatigue fracture of lead is intercrystalline and in a corrosive environment fresh crystal surfaces of metallic lead constantly are being exposed until the full depth of the metal is penetrated. Thus, indication of stress corrosion in lead is evidenced by more or less severe intercrystalline etching, sometimes to the point of fracture if the stress conditions are not removed or modified. Cracks from fatigue failures in lead pipe often are transverse and usually at the outside of a bend.

There are two approaches toward elimination of difficulties brought about by the above conditions:

1. Remove the source of stress.
  - a. This may be done by insulating the equipment from vibration or,
  - b. Spreading out the heating-cooling cycle or,
  - c. Lowering the peak temperature if possible.
2. If the source cannot be removed, counteract the effect by,
  - a. Providing adequate strapping to relieve stress caused by hanging or,
  - b. Use a homogeneously-bonded lead lining to counteract severe cyclic temperature changes or,
  - c. Protect the lead mechanically and thermally with a brick lining or,
  - d. Use thicker lead to reduce fibre stress.

Fatigue characteristics may vary with different alloys of lead. Chemical lead alloyed with 0.04 to 0.05 percent tellurium is amenable to work-hardening, an effect which normally takes place during the sheet rolling operation. The property of work-hardening coupled with the fact that the presence of tellurium in chemical lead acts as a grain growth inhibitor, raises the fatigue resistance of tellurium lead above that of unalloyed chemical lead.

### Galvanic Corrosion

Corrosion associated with the current of a galvanic cell made up of dissimilar electrodes is defined as galvanic corrosion. This also is known as "couple action."<sup>7</sup> Galvanic corrosion generally is understood to consist of the sum total corrosion, which comprises the normal corrosion that would occur on a metal exposed alone plus the additional amount due to contact with the more noble metal. Since all metals are electrically conductive, the possibility of galvanic corrosion taking place when two or more dissimilar metals come in contact in the same electrolytic medium is almost always present. However, in most chemical installations using lead in a corrosive electrolyte, galvanic corrosion usually is of little consequence and ordinarily is ignored. The film which forms on lead as a result of ordinary chemical reaction, in most instances, acts as an electrical insulator. This is true especially in sulfuric acid exposure, lead sulfate being practically non-conductive.

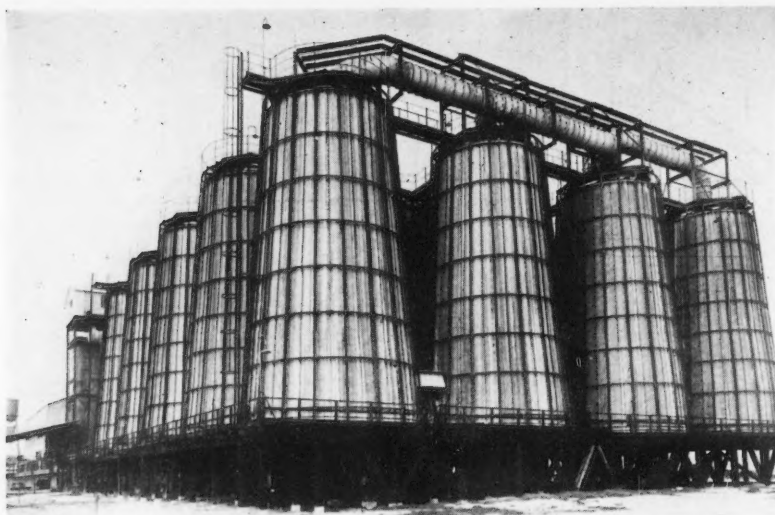


Figure 6. These Mills-Packard towers used in the manufacture of sulfuric acid by the chamber process are constructed entirely of sheet lead supported in a steel frame. The lead is cooled externally by water flowing down the sloping sides.

### Lead Specifications

#### Chemical Lead

The chemical properties of lead are coupled with its composition; hence, the selection of the proper grade of lead for a chemical installation cannot be left to chance. Just as with most metals, the presence of very small percentages of other metallic constituents may alter materially the chemical behavior of lead. Experiments with pure lead alloyed with very small percentages of some other metals reveal that its surface reactivity is markedly increased by the presence of these other metals. This means, for practical purposes, that when lead so alloyed is used with a corrosive, it develops a corrosion resistant film more rapidly than pure lead and also one whose characteristics such as cohesion and abrasion resistance may be altered.<sup>8</sup> This is probably another reason why chemical lead, the grade most commonly used by the chemical industry and containing 0.04 to 0.08 percent copper and 0.002 to 0.020 percent silver<sup>9</sup> is preferred to the purer corroding lead as a material for chemical construction, in addition to the fact that the presence of such fractional percentages of so-called "impurities" markedly increases lead's creep and fatigue strength. Any increase in strength naturally lowers the tendency for movement of the metal to rupture the protective film. Higher percentages of other constituents, depending upon the element, increase the rate of salt formation to a detrimental degree or in some instances alter the cohesion and abrasion resistance of the film, leading in either case to poor anti-corrosion characteristics.

#### Antimonial Lead

Antimonial or "hard" lead is used in place of chemical lead when greater mechanical strength is desired. Antimonial lead as used by the chemical industry usually consists of chemical lead alloyed with from 4 to 12 percent antimony. While it is less resistant to most corrosives, it does form a more rigid installation because it has greater strength at temperatures below 120° C (248° F) and consequently has a lower tendency to creep and warp at low tem-

peratures.<sup>10</sup> Also large quantities of antimonial lead are used in pumps, valves and pipe because it offers greater strength and resistance to flow abrasion than does chemical lead.

### Physical Properties

Lead's performance in the chemical industry both physically and chemically has been well documented. Sufficient performance records are available to make possible a description of the behavior of lead as a corrosive handling material from the viewpoint of its physical as well as its chemical characteristics. Physical and mechanical properties cannot be overemphasized in the case of lead; in many instances they are of greater significance to the plant engineer than chemical properties.

The physical characteristics of any metal destined for use in the chemical industry determined three important factors:

1. How it will act at various temperatures and pressures.
2. In what form the metal may be fabricated best or constructed to meet the requirements demanded in No. 1.
3. The economic aspects of maintenance and replacement.

The many ways in which lead's physical characteristics influence its value to the chemical industry as a material for handling and controlling corrosives are described herewith to guide those whose responsibilities involve specifying such materials.

#### Temperature Limits

Lead's usefulness at elevated temperatures is limited because of its melting point. Lead melts at 327° C (621° F). It may be used safely at temperatures up to 230° C (450° F) in the absence of stress corrosive conditions. Above this temperature, corrosion resistance and strength decrease to a degree making practical use questionable. The same safe working limits apply as well to tellurium chemical lead.<sup>3</sup>

Antimonial or "hard" lead containing 6 percent antimony can be recommended for use only up to about 120° C (248° F), although it has a solidus at 252° C (485° F). At temperatures higher than 120° C,

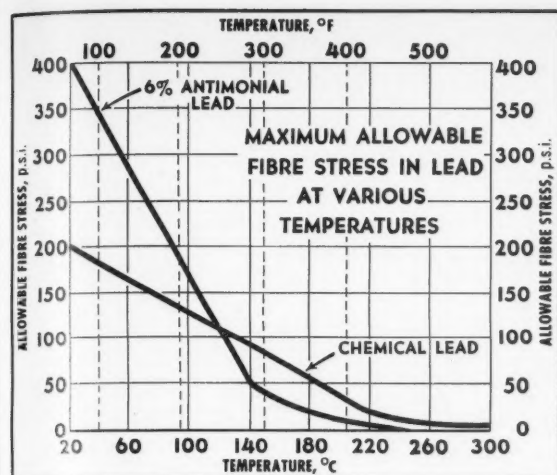


Figure 7. Maximum allowable fibre stress in chemical and 6 percent antimonial lead at various temperatures. Fifty pound saturated steam limits are at 148° C (298° F).

6 percent antimonial lead actually is less effective than chemical lead because it softens rapidly and usually corrodes more readily.

It is possible, in some types of equipment to operate in excess of the above temperatures by insulating or shielding the lead internally with acid-resistant brick or cooling the lead externally with water sprays. The lead in all Mills-Packard sulfuric acid chambers is kept cool by water flowing down the sloping sides. A typical installation is shown in Figure 6. Bonding lead directly to the shell as in homogeneous linings also permits operation at higher temperature ranges.

#### Pressure Limits

Steel and wooden tanks frequently are lined with lead to provide corrosion resistance. The tanks themselves should be designed to retain the hydrostatic pressure or any other pressures built up during operation of the vessel.

In deep tanks, because of the high density of lead (0.410 lbs. per cubic inch) loose linings must be strapped properly to overcome the effect of gravity. The maximum height of a uniformly cross-sectioned loose lead lining supported only from the top theoretically is 40 feet at a constant temperature of 20° C (68° F). The maximum height of an unstrapped lead lining at a constant temperature of 150° C (302° F) theoretically is 16 feet. In practice the optimum height of a loose lead-lined vessel without the benefit of any support from strapping rarely exceeds 8 feet, depending upon the weight of lead.

When lead is used to handle steam or water under pressure the maximum allowable hoop or fibre stress of chemical and tellurium lead is 200 psi at room temperature (20° C [68° F]); the maximum allowable fibre stress at 150° C (302° F) is 80 psi. Use of lead under pressure at higher temperatures is not recommended.<sup>10</sup>

Antimonial lead (6 percent), being stronger than soft lead, has a maximum allowable fibre stress of 400 psi at room temperature, but because it has a lower melting point the allowable fibre stress is only

50 psi at 140° C (284° F).<sup>10</sup> Figure 7 shows the maximum allowable fibre stress for chemical and 6 percent antimonial lead at various temperatures.<sup>11</sup>

Lead-lined vessels often are used under vacuum. One process for recovering and concentrating sludge acids successfully uses brick-lined sheet lead under vacuum as low as 0.25 inches of mercury. Just as under pressure, it is imperative that the shell of the vessel be sufficiently strong to resist collapse due to atmospheric pressure. When heat transfer is important, homogeneously bonded lead should be used.

#### Effect of Rate of Flow

Because lead is comparatively soft it is susceptible to erosion by fast-flowing liquids or liquids containing abrasives. Table II shows the effect of increasing the velocity of 20 percent sulfuric acid at 25° C (75° F) across the surface of lead.<sup>4</sup>

TABLE II

Velocity of Solution Across Lead Surface ft./min.	Rate of Corrosion in./month x 10 <sup>-3</sup>
8.4	55
97	17
155	16
300	86

The rates appear to fall with initial increase in velocity, but increase markedly at a velocity of 300 feet per minute. The erosion of lead pipe may be retarded by designing the system to reduce flow rate friction as much as possible, e.g. eliminate sharp bends, use larger pipe, or both. Lead pipe is especially useful when a high rate of flow is desired because it can be curved and assembled without extra fittings, and because extruded lead offers a minimum of surface friction. For relative surface smoothness of lead pipe according to the "Chemical Engineer's Handbook," is classified in the same category as glass.<sup>12</sup>

#### Fabrication and Equipment

Another very important physical characteristic of a metal destined for anti-corrosive use is its amenability to various methods of fabrication. Here lead enjoys a rather unique position insofar as one of its chief advantages over other metals is predicated on the number and variety of ways in which it may be fabricated. Sheet lead may be welded or "burned" to form a continuous lining; it may be bonded directly to another metal; it may be cast, die cast or pressure-molded; it may be extruded into pipe and a variety of shapes; and it may be fastened by welding, flanging, bolting or soldering. Once installed, lead chemical equipment is easily repaired with a welding torch and requires no annealing or subsequent heat treatments.

#### Soldering and Welding

In chemical applications, at least where corrosion is a factor, soldering is of little value because of the relative ease with which the tin-lead eutectic is attacked, plus the fact that tin substantially lowers lead's melting point. Lead welding, commonly called



lead "burning," is a simpler and much more satisfactory method of joining lead to lead without introducing any foreign metals. The ease with which this is accomplished when an experienced lead welder is used has contributed much to the widespread use of lead linings. Lead welding permits the fabrication of continuous impervious linings in vessels constructed of metals stronger than lead but without its corrosion resistance. Figure 8 shows lead welders working on a typical sheet lead installation. Many chemical plants operating with considerable lead equipment train and maintain their own lead welders for making minor repairs. When installing or building new equipment, they generally bring in more experienced lead welding contractors who are specialists.

#### Sheet Lead Linings

Sheet lead for lining all types, shapes and sizes of chemical equipment usually comes in rolls ranging from 8 to 12 feet wide and up to 60 feet long, depending on the thickness of the sheet. Twenty feet is generally a standard roll. Thickness varies from 1/80-inch to 2 inches, or measured in the parlance peculiar to the lead industry—3/4-lb. to 120-lb. lead. As an approximate rule of thumb, one square foot of lead 1/64 inch thick weighs about one pound and is called 1-lb. lead; 1/4 inch lead is called 16-lb; etc. Most

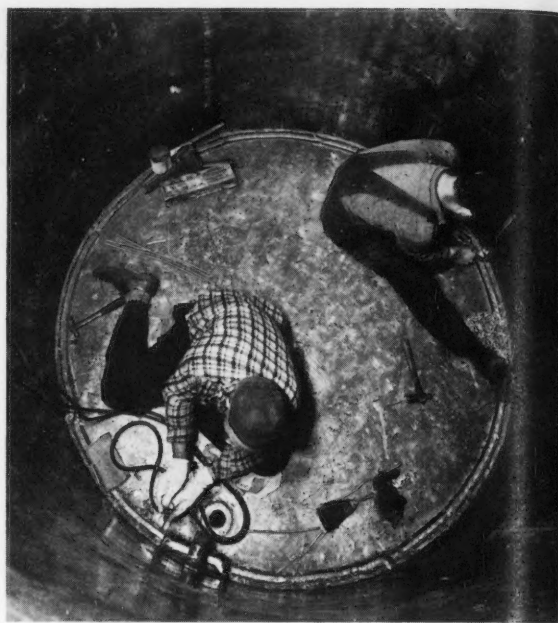
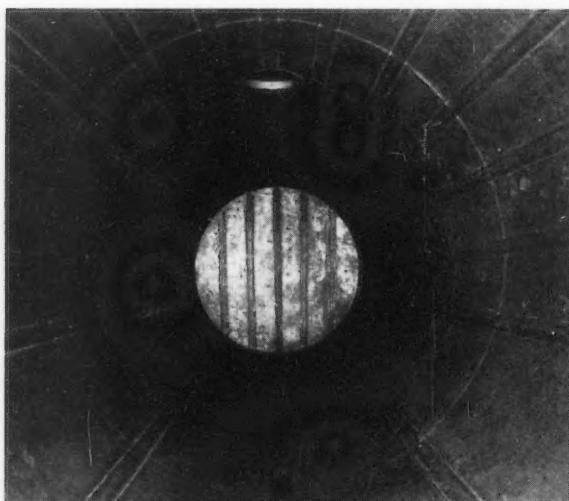


Figure 8. Welding the seams of a typical loose sheet lead-lined tank. The man at upper right is preparing the seams for welding by scraping the lead clean.



Figures 9-10. Lead-lined steel storage tanks 10½ feet in diameter and 38¾ feet long. Interior view, Figure 10, shows method of strapping. Note that the overhead strapping which must support the weight of the lead consists of 10 straps 1 foot 8 inches apart whereas the bottom half is fastened with only 6 straps 2 feet 9 inches apart. The vertical end straps are 1 foot 9 inches apart.



sheet lead is ordered cut to the size that will be used ultimately by the consumer. In some special applications, such as in the walls of Mills-Packard sulfuric acid chambers, a single sheet may be rolled with several different thicknesses.<sup>8</sup>

From the construction viewpoint, the most important aspect of effective sheet lead lining is the provision of adequate and proper support, usually by strapping. Specifications for lead linings depend on such factors as size of equipment, size or weight and grade of lead, temperature, corrosive conditions, type of shell (wood or steel), type and location of strapping, and others. Detailed discussion of such specifications warrants a special paper of its own. Generally speaking, sufficient strapping should be used in the right places to insure reasonable service performance and minimum stress corrosion, assuming of course, that the lead is known to be resistant to the

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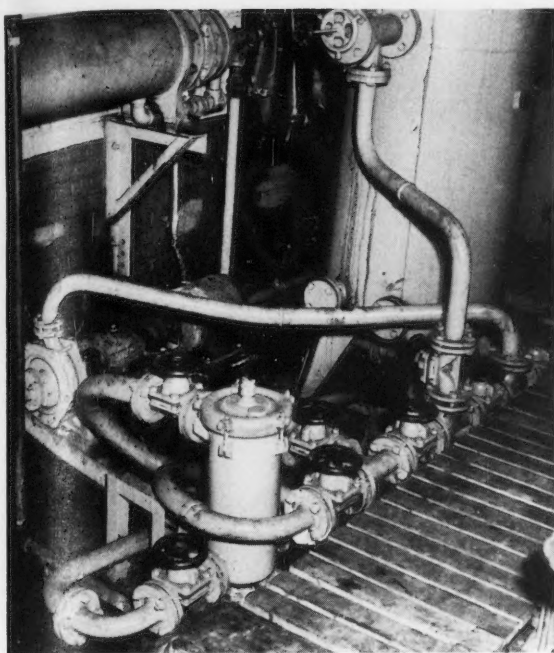


Figure 11. A complex piping system for recirculating corrosive electrolyte in a modern plating plant. All pipe and valves are made partially or entirely of lead.

corrosive under the same conditions of concentration, temperature and agitation to be encountered in that particular service. Figures 9 and 10 show an example of good strapping practice. The top strapping in Figure 10 which must support the weight of the sheet lead is placed at closer intervals than the bottom strapping which simply holds the lead in place, its weight being supported by the steel shell of the tank.

A case on record illustrates the importance of adequate strapping. The process is an especially severe one for a lead lining: the manufacture of alum by reacting sulfuric acid with alumina in a stream agitated lead-lined steel tank. By removing the original 16-lb. lead lining which was vertically strapped every four feet and installing 22-lb. lead with the distance between straps reduced to two feet the service life of the vessel was tripled.<sup>13</sup>

Horizontal strapping in lieu of vertical strapping seldom is used, particularly when under-hand welding is involved. Occasionally in tanks more than 10 feet deep one or two horizontal straps are used in conjunction with the usual vertical strapping to help support the weight of lead.<sup>14</sup>

#### Homogeneous Linings

Under severe temperature conditions, particularly when wide fluctuations are necessarily used over a short period of time such as in batch processing and various cyclic reactions, two different methods may be adopted to prevent undue shortening of the lead's normal service life. The method most often used and one which has performed very well in service is to bond the lead to the steel shell of the equipment, forming what is termed a homogeneously bonded

lining. For high temperature service (up to 320° C. [450° F.]) lead is bonded directly to the steel; at lower temperatures the lead may be joined to the steel with the aid of a thin lead-tin solder film. While this method of lining with lead is more expensive, the extra cost is usually more than compensated for by a substantial increase in the life of the equipment.

Homogeneous lead linings always should be employed for jacketed vessels where heat transfer is important because any air space between the lead lining and the shell of the vessel results in a reduction in the efficiency of heat conduction. Many bottom-jacketed reaction tanks are lead-lined on the sides and bonded on the bottoms.

#### Acid-Brick Linings

A second method of protecting lead-lined vessels from temperatures close to lead's softening range or from erosion effects is to cover the lead with an inner lining of special acid-resistant brick. A natural question is: If the bricks are acid-resistant, why use a lead lining? Unfortunately practically all bricks will spall or crack after repeated heating and cooling and eventually, even after operation at continuous temperature, tiny cracks will develop in the brick lining permitting the corrosives to seep through to the outside. Bricks also will spall when they absorb saturated solutions which crystallize on cooling. As a matter of fact, no cemented conglomerate such as brick can be as impervious to liquids as a metal. With nothing to protect it, the supporting shell of the vessel will be attacked by the seeping corrosive and eventually require expensive repairs and probably replacement. The lead acts as insurance against this occurrence. Any seepage will be retained by the lead until the brick lining can be repaired.

A large by-product sulfuric acid plant has been using a brick-lining over lead in its humidifying chamber for handling corrosive sulfur dioxide and sulfur trioxide at 290° C. (554° F.). The linings consist of 20-lb. lead with three courses of brick on the bottom giving a total thickness of 9 inches and a single 12-inch course over 10-lb. lead on the lower sides thinning to a 9-inch course above. The thicker 12-inch lining is simply to provide extra support for the brick above. This equipment has been in use for eleven years.<sup>15</sup>

#### Lead and Lead-lined Pipe

Lead is extruded readily into various shapes and large quantities of extruded lead pipe are used by the chemical industry. Sizes are limited only by extrusion equipment and may include a large number of combinations of wall thickness and outside diameter as well as shapes of cross-section. An advantage of lead pipe is that it is readily bent to conform to intricate design specifications. Figure 11 illustrates a complex pipe and valve system made up entirely of lead. Because of lead's weight, it is frequently advisable to support it either by strap hangers or continuous support such as laying it in steel channels. This is why lead-lined steel or cast iron pipe frequently is used when the corrosion resistance of lead is demanded,

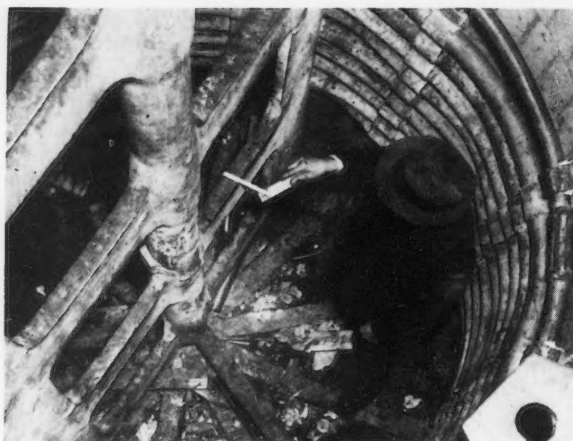
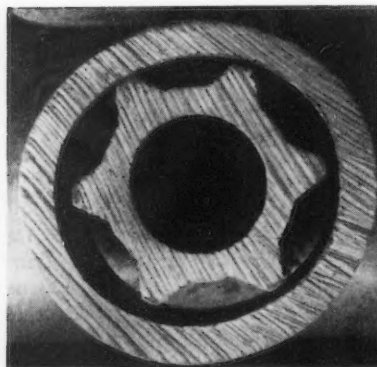


Figure 12. View through the manhole of a brick-lined reaction vessel 18 feet deep and 8½ feet in diameter used for treating mixtures of sodium bichromate and sulfuric acid at 100° C (212° F). The tellurium-lead coils installed in 1939 are still being used to heat the chemical solutions with steam under 30 pound pressure. Cooling water is pumped through the coils after the reactions are completed. The steel agitator is homogeneously bonded with chemical lead ¾ inch thick.

but when the temperature is high and the expense of supporting the pipe is disproportionate. Steel or iron pipes with lead linings inside are made by one of two methods: extruded lead pipe hydraulically expanded inside an iron or steel pipe, or homogeneously bonded to it.

#### Lead Heating Coils

Lead pipe has found wide acceptance for use as heating or cooling coils. Figure 12 shows the lead steam coils used for heating a large brick-lined vessel with a rounded bottom. Note the cast lead form used to support the coils. Maximum steam pressure and corresponding temperature limits for different pipe sizes are shown in Table III.



Figures 13-14. Heat exchanger coils consisting of one lead pipe within another permitting countercurrent flow of a corrosive coolant. The cross-sectional view of the exchanger coil in Figure 14 shows the specially shaped extruded inner pipe in position.

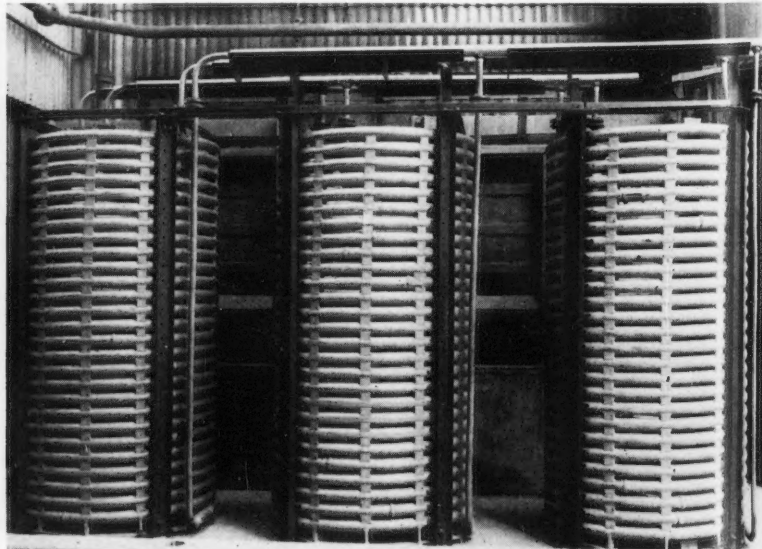


Table III

Inside Diameter of Pipe, Inches	Outside Diameter of Pipe, Inches	Weight per Foot		Maximum Steam Pressure, p.s.i.	Corresponding Temperature Limit, °F.
		Lbs.	Ozs.		
¾	1.006	1	12	30	274
¾	1.156	3	0	40	287
¾	1.212	3	8	50	298
1	1.356	3	4	30	274
1	1.492	4	12	40	287
1	1.610	6	2	50	298
1¼	1.670	4	12	30	274
1¼	1.889	7	12	40	287
1¼	2.012	9	10	50	298

Copper coils covered with bonded lead have been developed for greater thermal conductivity and strength at higher steam pressures without sacrificing corrosion resistance. Such coils are operated up to 150 pounds steam pressure.

One of the latest developments illustrated in Figures 13 and 14 consists of using two lead pipes, one within the other, resulting in a double action heating and cooling heat exchanger. The inside pipe is extruded with its cross-section in the shape of a six pointed star with a round hole in the center. In this manner the cross-sectional area of the space between the two pipes very nearly equals the cross-sectional area of the inside of the inner pipe. The points of the star also serve to keep the two pipes concentric. With this arrangement it is possible to permit countercurrent heating in one pipe while cooling in the other.

Ribbed and finned lead pipe are used in many systems requiring greater surface area. Lead sheathed electric heating devices have been used successfully in place of steam heated coils in some installations where raising steam is difficult or hazardous or where electricity is inexpensive.

#### Castings and Valves

Large quantities of lead are used by the chemical industry in the form of castings. Ordinary chemical

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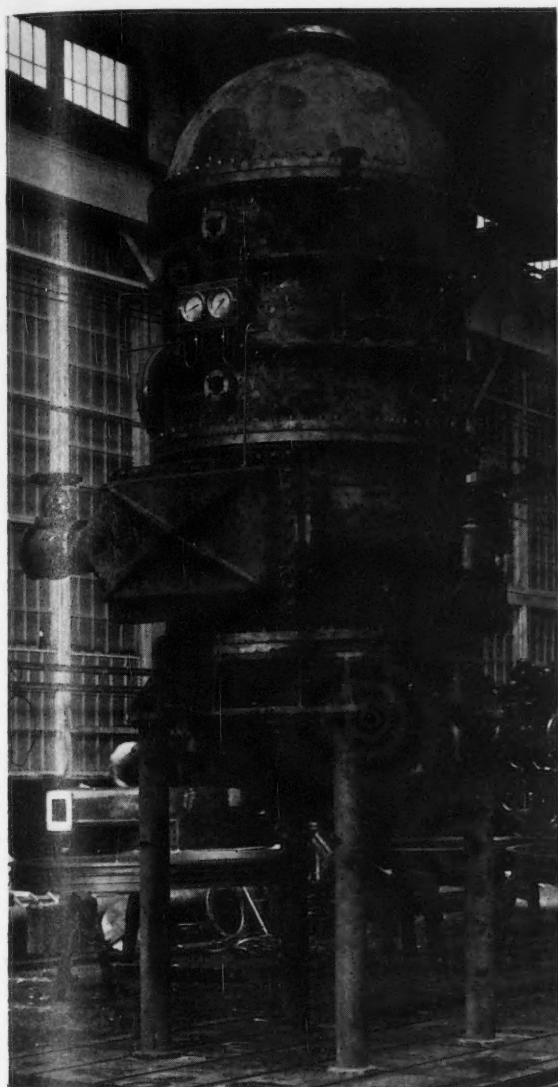


Figure 15. Seventeen-ton evaporator made entirely of cast 8 percent antimonial lead and used for concentrating titanium sulfate solution.

lead, usually too soft for this purpose, is alloyed with various percentages of antimony. Lead hardened in this manner is cast into pumps and valves as well as many special shapes and fittings. A typical piece of cast lead chemical equipment shown in Figure 15 is an evaporator for concentrating titanium sulfate solution. It is made entirely of separate castings of 8 percent antimonial lead bolted together into one unit measuring  $4\frac{1}{2}$  feet in diameter and 7 feet high. About 35,000 pounds of metal were required to make the castings.<sup>16</sup> Even larger cast lead evaporators six feet to eight feet in diameter are quite common. Cast lead plate and frame filter presses and cast lead rotary vacuum filters are built in all sizes.

Lead valves frequently are equipped with plugs and seats made of abrasion-resistant materials such as Lucite, Bakelite, Hastelloy and others, thus reducing the wear on those parts.

### Economic Aspects

The economic aspects of maintenance and replacement hinge on both the metal's physical characteristics and its salvage value. Lead suffers very little from change in weight or structure due to corrosion; thus it can be maintained at low cost or salvaged at a high value.

Fabrication costs are low in the case of lead. Present prices show that the pig lead or raw material represents as much as 80 percent of the cost of fabricated sheet and pipe.<sup>17</sup>

Scrap lead is easily remelted and refined and volume losses under most corrosive conditions are so slight that as a result lead has an unusually high salvage value which may run as high as 75 percent of the original cost of new sheet and pipe, depending upon market conditions.

### Summary and Conclusions

A study of the successful performance of lead equipment in the chemical industry shows that such performance is intimately associated with lead's physical characteristics as well as its chemical or corrosion characteristics. Lists of chemicals with comments and data describing their reaction with lead, such as appeared in the December, 1946 issue of CORROSION, are available.<sup>18</sup> Lead companies and fabricators and the Lead Industries Association may be consulted. Inasmuch as advice can at best be only a prediction based on past performance, the most practical procedure is to test a sample of the lead under conditions as close as possible to actual service.

No set rule can be stated governing the reaction of lead with all corrosives. Comparative corrosion rate data based on volume loss or weight loss can be misleading in the case of lead insofar as it is thicker and more dense than other corrosion resistant materials. Generally, the corrosion rate increases with increase in temperature. The effect of concentration varies with the corrosive. Chemicals containing dissolved oxygen usually lower lead's resistance. Fatigue accompanied by corrosion promotes stress corrosion, a condition which may be controlled by removing the source of stress or counteracting its effect. Galvanic corrosion in the case of lead is seldom encountered because an insulating coating normally develops which prevents or minimizes couple action.

While lead has certain physical limitations as a construction material, they usually can be overcome by proper installation. The maximum allowable fibre stress for chemical lead is 200 psi at room temperature; antimonial lead, being stronger, has a maximum allowable fibre stress of 400 psi at the same temperature. Chemical lead's usefulness at high temperatures is limited to about 230° C. (450° F.) while antimonial lead (6% Sb), because of its lower melting point, is limited to about 120° C. (248° F.). The erosion of lead by fast-flowing or abrasive liquids may be retarded by proper design.

Lead can be fabricated easily to meet special conditions. Sheet lead-lined vessels usually are supported by vertical strapping, the type and location of which is very important. Conditions such as temperature

fluctuation, high pressure or vacuum, or heat transfer can be met with homogeneous linings or, excepting heat transfer, by a brick lining over the lead. Lead pipe, heating coils, castings and valves can be made to cope with a variety of special conditions.

Because of the manner in which lead corrodes coupled with its smelting characteristics lead in all forms can be reclaimed and sold as salvage at a high return.

Therefore, if lead's mechanical and physical properties are recognized in making installations, it is widely favored as a material of chemical construction because chemically it is little affected by so many corrosives.

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### DISCUSSION

**Question by Hugh P. Godard, Aluminum Laboratories, Ltd., P. O. Box 84, Kingston, Ontario, Canada.**

"How does lead behave in contact with brick mortar and concrete? We have experienced perforation of lead sheet placed beneath a tiled shower room floor and attributed it to the mortar."

#### Author's Reply:

Like some other metals, lead may at first react with the alkalis, notably free lime ( $\text{CaO}$ ), found in freshly poured ("green") concrete or brick mortar. However, after a sufficient lapse of time to allow the concrete to become "cured," the lime becomes converted to calcium carbonate ( $\text{CaCO}_3$ ) which has no effect on lead. It is a recommended practice to coat lead with a layer of asphaltum or tar if it is to be used in direct contact with fresh concrete or brick mortar. This effectively protects the lead against corrosion during the "curing" cycle. Incidentally, this method of protection has proven itself acceptable by widespread and continued application in the field.

The mortar used on the brick linings referred to in the above paper is of a different nature than ordinary mortars and does not effect the lead membrane whatsoever.

**Comment by R. R. Rogers, Bureau of Mines (Canada), Ottawa, Canada:**

"In our laboratory we have found that small additions of lithium increase the corrosion resistance of zinc and aluminum under a number of different types of exposure. I would like to inquire if you have any information regarding the effect of lithium on the corrosion resistance of lead. I also would like to ask the same question regarding calcium additions to lead."

#### Author's Reply:

Little published information is available about the corrosion resistance of lead alloyed with lithium. It may be safely assumed that its behavior will parallel somewhat that of calcium but to a greater extent. Alloys in the order of 0.1 percent both Li and Ca definitely do not add to lead's corrosion resistance and when present in greater quantities they noticeably detract from its corrosion resistance in many environments. Both are known to improve lead's physical properties. Calcium lead has been used successfully in several applications where corrosion is a minor factor, but where improved physical characteristics are significant.



# Topic of the Month

## Application of Alloy Steel Linings to Tanks Storing Corrosive Pulp Cooking Liquor \*

By H. A. SCHMITZ\* and M. A. SCHEIL\*\*

**S**ULPHITE pulp cooking liquors customarily have been stored in wooden tanks when operating conditions are atmospheric temperature and pressure, and in ceramic-lined steel tanks when higher pressures and temperatures are involved.

Wooden storage tanks present a costly maintenance and replacement problem and ceramic linings also are a problem because of the necessity of replacing the lining.

Another consideration in connection with storage of these corrosive liquors is the absorption of gases during and after the cooks, necessitating equipment capable of withstanding pressure to give better and more uniform absorption.

Because cooking liquors are highly corrosive it was necessary to conduct a testing program to determine which of the available alloys was best suited and most practical for the operating conditions involved.

A number of grades of alloy processed to duplicate fabricating conditions for field-erected vessels were exposed to actual operating conditions. Included in the test program were specimens of alloy representing spot and arc welding, and the susceptibility of the specimens to stress corrosion was investigated by exposing appropriate specimens stressed elastically and plastically.

The photographs of test specimens show the manner in which they were prepared for study of this corrosion problem.

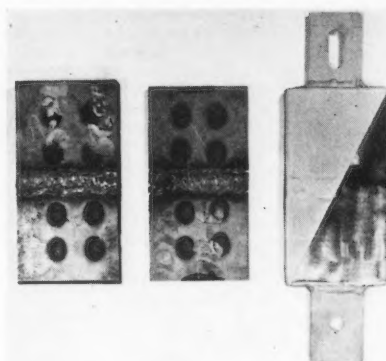
Of the various materials tested, Type 347 and Type 316 low-carbon alloys were found to have considerable advantage over other materials tested. Type 347 is used in tanks which operate at atmospheric temperatures and Type 316 for elevated pressures and temperatures.

After more than ten years' operation, an acid storage tank for sulphite liquor designed for 25-pound pressures and measuring 20 feet inside diameter by 29 feet, 5 inches from head to head shows no sign of corrosion in either the vapor or liquid phases. This vessel was lined with Type 347 alloy approximately  $\frac{1}{4}$ -inch thick.

Since the installation of this tank six more tanks have been erected and put in service. Two are operating at 45-pound pressures and are lined with Type 316 low-carbon alloy. These vessels are approximately 24 feet in diameter and 30 feet between heads.

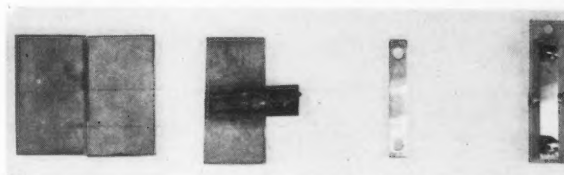
Besides reducing maintenance cost to a very low figure the alloy lining resulted in a considerable increase in capacity for the same outside area. Successful use of stainless steel alloys for this type of service is the result of a careful testing program made under operating conditions. Results from these tests indicate the data obtained definitely is valuable in determining how alloys will stand up in the fabricated vessel under operating conditions.

Preparation of Corrosion Test Paddle



1—7/64-inch alloy liner spotwelded to  $\frac{1}{2}$ -inch carbon steel plate. 2—Pass alloy deposit represents main seam weld. 3—Carbon steel machined to  $\frac{1}{4}$ -inch overall thickness and scarfed for seal welding. 4—Finished paddle with duplex surface preparation: Sandblast and 120 grit polish.

Preparation of Beam-type Stress Corrosion Specimens



1—7/64-inch alloy liner plates scarfed for welding. 2—Full penetration alloy weld. 3—Weld beads ground flush and polished with 120 grit. 4—Specimen mounted and stressed 40,000 psi.

Preparation of Cross-weld Corrosion Specimen



1—7/64-inch alloy liner as received  $2\frac{1}{4}$ -inch by  $3\frac{1}{4}$ -inch. 2—Cross weld of single bead alloy deposit. 3—Weld bead ground flush. Machined to 2 inches by 3 inches. 4—Finished specimen identified, sandblasted, polished with 120 grit.

\* Sales Engineer, A. O. Smith Corporation.

\*\* Director of Metallurgical Research, A. O. Smith Corp., Milwaukee, Wis.





# NACE News

## Short Course Registration Is Under Way

Official applications for registration at the Short Course in Corrosion are being sent out now from Central Office NACE and most of the details respecting the course excepting two lecturers, now are known, it was revealed by R. A. Brannon, Humble Pipe Line Co., who is chairman of the committee on arrangements. Persons who plan to attend the course are urged to request an official registration application at once from A. B. Campbell, Executive Secretary NACE, 919 Milam Building, Houston, Texas. The application blank will carry on its reverse side substantially all the information a person attending will need to know.

Those attending are asked to report before class time Monday at Room 118, first floor, Chemistry Building.

### TENTATIVE SCHEDULE SHORT COURSE IN CORROSION

University of Texas, Austin  
September 12-16, 1949

Monday		
Sept. 12	9:00 - 12:30 p.m.	Fundamentals
	7:30 - 10:30 p.m.	Fundamentals
Tuesday		
Sept. 13	9:30 - 11:30 a.m.	Metallurgy
	7:30 - 10:00 p.m.	Types of Corrosion
Wednesday		
Sept. 14	9:00 - 11:30 a.m.	Corrosion resistant metals
	7:30 - 10:00 p.m.	Protective coatings
Thursday		
Sept. 15	9:00 - 11:00 a.m.	Cathodic protection
	7:30 - 10:00 p.m.	Cathodic protection
Friday		
Sept. 16	9:00 - 11:30 a.m.	Chemical treatment

Lecturers who have accepted are as follows:

Metallurgy—F. A. Prange, Phillips Petroleum Co., Bartlesville, Okla.

Corrosion-Resistant Metals—Frank LaQue, The International Nickel Co., Inc., New York.

Cathodic Protection-Practical Aspects—A. W. Peabody, Ebasco Services, Inc., Jackson, Miss.

Cathodic Protection-Theoretical Aspects—Scott P. Ewing, Carter Oil Co., Tulsa, Okla.

Types of Corrosion—L. G. Vande Bogart, Crane Co., Chicago, Ill.

Fundamentals—Dr. Norman Hackerman, University of Texas, Austin.

### Motion Pictures

Afternoon showing of motion pictures pertinent to the course has been arranged. Titles of two under consideration are "Electrochemistry," scheduled for showing on Monday and "Steel and Metals," scheduled for showing on the second day. Several more pictures are being secured, titles of which will be announced later.

### Application for Registration

Central Office NACE will send to

those who request them duplicate applications for registration, both copies of which are to be filled out and returned to Central Office NACE. The duplicate copy of the application will be endorsed, and will constitute a receipt for fees paid and a notification that the registration has been accepted.

Because the number that may be accommodated at the course is limited to 250, no more than that number of applications will be accepted. If more than 250 applications are received, those who apply after the course is filled will be notified and their remittances returned.

Fee for the course is \$20. This fee covers all or any part of the course, and must be paid in advance along with application for registration.

### Housing Arrangements

For those who wish to take advantage of them, the University will make available to those taking the course dormitory rooms on the campus.

Following are details of dormitory rooms:

1. Cost, \$1.50 per night.
2. Rooms not air conditioned and fans and towels are not furnished.
3. Rooms must be engaged and paid for in advance at the same time the application for registration is made.
4. No refund will be made on room fees.

5. Rooms will be assigned at a dormitory to be designated later. Rooms will be available beginning at 10 a.m., September 11.

6. Persons who reserve rooms may get information on their location after reaching Austin by calling either Dr. Norman Hackerman at 6-5222 or Mrs. Eleanor Blair at 7-4960.

7. Rooms in dormitories must be released by noon, Friday, September 16.

Persons who wish to stay elsewhere must make their own arrangements for lodging.

### NACE HAS MOVED!

NEW ADDRESS

919 MILAM BLDG.

803 TEXAS AVE.

HOUSTON 2, TEXAS

### NACE CALENDAR

**NORTH EAST REGION**—Board of trustees meetings scheduled September 22 and November 18.

**METROPOLITAN NEW YORK SECTION**—Meetings are scheduled Sept. 28 and Nov. 9, 1949; Feb. 8 and May 10, 1950.

**PHILADELPHIA SECTION**—Governing Board meeting scheduled October 31. Section dinner meetings scheduled September 12 and December 12.

**GREATER ST. LOUIS SECTION**—Meets third Monday monthly. No meetings June, July, Aug., and September.

**SHREVEPORT SECTION**—Will hold no meetings during July and August. Regular meeting day is second Thursdays monthly.

**TULSA SECTION**—Meets Second Monday monthly.

**NORTH TEXAS SECTION**—Will hold its next meeting during September.

A. B. Campbell, Executive Secretary  
National Association of Corrosion Engineers,  
919 Milam Building, Houston 2, Texas

I am interested in the SHORT COURSE ON CORROSION.  
Please Send Official Registration Application to the Address Below:  
(Print or typewrite plainly)

Name .....

Street .....

City..... Zone..... State.....

# South Central Region Meets in October

## Nine Technical Papers and Corrosion Panel Discussion Are Scheduled for Session

Nine technical papers, a corrosion panel discussion and a Fellowship Hour and Buffet Supper will be features of the annual meeting of South Central Region NACE at the Adolphus Hotel, Dallas, October 3 and 4. Registration forms have been mailed to association members and others in the South Central and South East regions and questions for the corrosion panel session are being collected. Any outside of these regions who wish to attend should arrange for accommodations directly with the Adolphus Hotel, Dallas, Texas.

The tentative schedule of arrangements for the meeting includes committee meetings on Sunday, October 2. Several of the Technical Practices Subcommittees of the national NACE organization have been invited to meet during the session.

On Monday, first item will be registration, followed by a business meeting. The afternoon will be devoted to the panel discussion on corrosion problems. L. F. Scherer, Texas Pipe Line Co., Houston, will act as moderator. Members of the panel will include F. L. LaQue, The International Nickel Co., Inc., New York; W. F. Rogers, The Gulf Refining Co., Houston; William E. Huddleston, Huddleston Engineering Co., Bartlesville, Okla.; Bruce L. Corey, Socony-Vacuum Oil Co., Inc., Topeka, Kansas, and H. D. Murray, The Texas Company, Midland, Texas.

Written questions for this panel will be accepted by L. F. Scherer, and others will be accepted during the session. Contributions of information and comments from those present is solicited. It was emphasized that there will be no record of any kind made of this session for publication.

Titles of technical papers and their authors follow:

"Causes of Corrosion in Airplanes and Methods of Prevention," by N. H. Simpson, Chief Chemist, Consolidated Vultee Aircraft Corp., Fort Worth Div.  
 "Selection of Protective Coatings for Fume Resistance," by C. C. Harvey, Ethyl Corp., Baton Rouge, La., plant.  
 "Thermoform Catalytic Cracking Gas Plant Corrosion Survey," by Christopher A. Murray, The Pure Oil Co., Smith's Bluff Refinery, Nederland, Texas.  
 "Let's Play Doctor," by William A. Crenshaw, American Inspection Service, Midland, Texas.

"Control of Vapor Zone Corrosion in Storage Tanks by the Use of Ammonia," by S. T. Gardner and A. T. Clothier, The Carter Oil Co., and Francis Corvelli, Interstate Oil Pipe Line Co., Tulsa, Okla.

"Corrosion Control on Gas and Water Distribution Systems on Texas Low Rent Housing Projects," by C. R. Goodrich, Ft. Worth, Texas.

"Combating Corrosion in a Chemical Plant with Magnesium Anodes," by Oliver Osborn, The Dow Chemical Co., Texas Div., Freeport, Texas.

"Installation and Economics of Placing Magnesium Anodes at Leaks Repaired on a Pipe Line," by J. A. Holloway, Houston Pipe Line Co., Edna, Texas.

"Experience with Two Graphite Ground Beds in Dry Lakes," by R. J. Emerson, El Paso Natural Gas Company, El Paso, Texas.

Following is a list of manufacturers and suppliers and their representatives who are supporting the Fellowship Hour and Buffet Supper:

Aluminum Co. of America, Charles D. Brown, 1806 Commerce Bldg., Houston, Texas.

Brance-Kracy Co., Inc., Wayne E. Broyles, Houston, Texas.

Cathodic Protection Service, E. P. Doremus, 1801 Bissonnet, Houston, Texas.

Cathodic Servicing Co., Miles Carmichael, Oklahoma City, Okla.

Chemical Engineering Co., K. M. Fancher, Dallas, Texas.

Chicago Bridge & Iron Co., Sam Hamilton, Chicago, Ill.

M. J. Crose, Mfg. Co., Inc., M. J. Crose, Tulsa, Okla.

Crutcher-Rolfs-Cummings, Inc., E. L. Rolfs, Houston, Texas.

Dearborn Chemical Co., Carl B. Smith, Chicago, Ill.

Dowell, Inc., Y. W. Titterington, Tulsa, Okla.

Hill, Hubbell & Co., Div. General Paint Corp., Robert A. McCarthy, Dallas, Texas.

W. E. Huddleston Engineering Co., W. E. Huddleston, Bartlesville, Okla.

Johns-Manville Sales Corp., F. W. Hodson, Houston.

The Koppers Co., Inc., Frank E. McNulty, Tulsa, Okla.

Keith Kote Co., Cecil Keith, Grand Prairie, Texas.

F. H. Maloney Co., F. H. Maloney, Houston.

James E. Mavor Co., T. P. Kelly, Houston.

Mayes Bros. Co., Inc., H. B. Mayes, Houston.

Midwestern Engine & Equip. Co., Inc., O. E. Murrey, Tulsa, Okla.

M. C. Miller Co., M. C. Miller, New York City.

Natasco Co., J. C. Nicholson, Tulsa, Okla.

National Carbon Co., Inc., Fred B. O'Mara, Dallas.

Non-Corrosive Products Co., of Texas, Anthony J. Mendive, Houston.

Owens-Corning Fiberglas Corp., James L. Neal, Dallas.

Perrault Bros., Lewis Perrault, Tulsa, Okla.

Pipe Line Service Corp., F. C. Yeazel, Franklin Park, Ill.

Pittsburgh Coke & Chemical Co., Russell H. Coe, Pittsburgh, Pa.

Plastic Engineering & Sales Corp., R. M. Cole, Ft. Worth.

Service Engineers, Inc., James A. Clay, Ft. Worth.

## Air Conditioned Buses To Carry Tank Tourers

Air-conditioned busses will transport those attending the annual Permian Basin Corrosion Tour, it has been announced by the publicity committee of the event. The tours have been arranged for smaller groups to make it possible to cover every corrosive area in the Permian Basin. Program for the tour will be the same essentially as last year, with tours during the day and meetings in the evening for reports and discussions of the day's inspections.

More than 150 manufacturers and applicators of corrosion control materials have been invited to participate and there are indications the 50 exhibit spaces available all will be taken. The exhibits, to be shown at Midland, will cover drilling, production and refining. Many of last year's exhibitors are expected to be back again.

Dates for the tour, September 27-30, were set to permit attendance at the South Central Region Meeting in Dallas October 3-4. Final day of the Permian Basin tour will be featured by a barbecue dinner.

Persons who plan to attend the tour are urged to mail their notice of intention to be present, along with the \$15 registration fee as soon as possible to: Registration Committee, Permian Basin Section NACE, Box 789, Midland, Texas.

Permian Basin Section's May 25 meeting at the Gulf Oil Building, Odessa, Texas was featured by a discussion on the subject of "Methods Used to Prevent Corrosion in Sour Crude Fields in West Texas," led by A. Gensberg of Gulf Oil Corp.

Committee chairman reported on the progress of arrangements for the annual fall corrosion inspection tour.

It was decided to postpone election of new officers until January, 1950.

Corpus Christi Section held its June meeting at the Princess Louise Hotel, Corpus Christi on the twenty-second. B. F. Heye, efficiency and results engineer for Central Power and Light Company spoke on "Treating of Cooling Tower Water to Control Corrosion." Following the address the pipe liners and plant men held separate discussion groups of local problems and methods.

Official programs for the South Central Region Dallas meeting are expected to be mailed before the end of August. Copies are available on request from Central Office NACE.

Standard Pipeprotection, Inc., Hugh W. Baird, St. Louis, Mo.

D. E. Stearns Co., D. E. Stearns, Shreveport, La.

John D. Trilsch Co., John D. Trilsch, Houston.

## 48 Attend Meeting of San Francisco Section

San Francisco Bay Area Section held a dinner meeting June 7 with 48 members and guests present. The success of the dinner meeting, which was featured by a talk by Henry P. Zeh, Standard Oil Co. of California, Richmond, Cal., on "Corrosion Protection of Oil Refinery Equipment," has resulted in plans to hold a larger number of dinner meetings in the future.

Mr. Zeh outlined a system for keeping a complete corrosion history and record of all equipment in the various units of a refinery. The method consists of keeping a card for each unit on which is a complete flow diagram, coded by colors to indicate corrosion areas. Data includes date of installation of changes, corrosion rates, metallurgy, metal thicknesses, stocks being processed, including rate and analysis, pressures, temperatures, etc. Mr. Zeh also discussed corrosion patterns observed relative to sulphur content and naphthenic acid content of stock processed and gave typical examples of corrosion of process equipment. Also discussed were the economics of linings vs. corrosion allowance and the use of large pilot plants for procurement of corrosion data.

Second feature of the evening was the "Corrosion Clinic," which has proved very popular. The general discussions during the "clinics" frequently make it possible to solve or clarify many interesting and baffling corrosion problems.

## Pittsburgh Section Holds Election of Officers

Pittsburgh Section's new officers, elected during joint meeting with the Pittsburgh Section of the Electrochemical Society June 10 at Pittsburgh, are as follows: Russel H. Coe, chairman; V. V. Kendall, vice-chairman; J. M. Bialosky, treasurer; E. D. Verink, Jr., secretary, and W. W. Binger, assistant secretary.

The joint meeting was featured by a program beginning at 1 p.m. including: "Dust to Dust," by Norman Peifer, Manufacturers Light, Heat and Power Co., Pittsburgh, Pa.; "Some Controlling Factors in Corrosion," by R. H. Brown, Aluminum Research Corp., New Kensington, Pa.; "Electroplating on Magnesium," by Dr. H. A. Robinson, Assistant Director, Magnesium Research Laboratories, Dow Chemical Company, Midland, Mich.; "The Effect of Composition on the Corrosion Resistance of Ferrous Metals," by C. P. Larrabee, Carnegie-Illinois Steel Corp., Vandergrift, Pa.; "Surface Reaction Studies Using Radioactive Tracers," by Dr. C. E. Birchenall, Metals Research Laboratories, Carnegie Institute of Technology, Pittsburgh, Pa.; and "Titanium Alloys," by Dr. P. H. Brace, Westinghouse Research Laboratories, East Pittsburgh, Pa.

## Brochures and Contracts for 1950 NACE Conference Booth Space Are Ready



O. E. MURREY

Midwestern Engine & Equipment Co., Tulsa, Okla., has accepted the chairmanship of the Exhibits Committee for the second successive year.

## Nine Symposia Are Scheduled for 1950

Nine symposia and two round-table sessions are scheduled tentatively for the 1950 National Association of Corrosion Engineers conference scheduled to be held April 3-7 inclusive, at the Jefferson Hotel, St. Louis. A. Wachter, chairman of the technical program committee, points out that under this program eight industry symposia will be held on Wednesday and Thursday, two symposia running concurrently on each day, morning and afternoon. Afternoon sessions would be shorter than morning sessions and would start at 2:30 p.m. instead of 2:00 p.m. as in former years.

Other items on the program include: Monday—Committee meetings.

Tuesday—General business meeting, morning. Corrosion Principles symposium, afternoon.

Scheduled for Wednesday and Thursday are the following symposia: Pipe Line Corrosion, Food Industry, Oil and Gas, Transportation, Chemical, Cathodic Protection, Fresh and Salt Water, Protective Coatings.

Friday—General Corrosion Problems Round Table, morning. Pipe Line Protection Round Table, morning.

Dr. Wachter has requested symposia chairmen to ask authors of papers to prepare them so they may be presented in 25 to 30 minutes, in order that at least 10 minutes may be available for discussion.

Diversified subject matter and a division equally between theoretical and practical is desirable within each symposium, Dr. Wachter says.

Distribution of brochures and contracts for booth space at the NACE 1950 Conference and Exhibit in St. Louis, Mo., April 3-7 is planned tentatively for August 1. O. E. Murrey, exhibits committee chairman, has announced.

More booth space than was available at the 1949 Cincinnati conference is indicated. Seventy-five booths are expected to be available at the New Jefferson Hotel. Space allocations and arrangements will be made at Central Offices NACE, 919 Milam Building, Houston 2, Texas. Inquiries respecting the exhibits should be directed to A. B. Campbell, Executive Secretary, at that address.

Motion pictures on corrosion topics will be shown again next year, it also was announced. Information about this feature of the exhibit also can be secured from Central Office.

## Three Past Presidents Head 1950 Symposia

Three past presidents of the National Association of Corrosion Engineers have accepted technical program chairmanships in the 1950 Conference to be held April 3-7 at New Jefferson Hotel, St. Louis, Mo. Dr. A. Wachter, chairman of the technical program committee, said Russell A. Brannon, Humble Pipe Line Co., Houston; F. J. McElhatton, Panhandle Eastern Pipe Line Co., Kansas City, Mo., and F. L. LaQue, The International Nickel Co., Inc., New York, all past presidents, will head sections of the program.

Chairman and co-chairman of seven symposia scheduled to be held at the NACE 1950 Conference at the New Jefferson Hotel, St. Louis, Mo., April 3-7, 1950, have been named as follows by Dr. A. Wachter, chairman of the Technical Program Committee:

### Pipe Line Corrosion Symposium

R. A. Brannon, Humble Pipe Line Co., Houston, chairman; S. S. Smith, Products Pipe Line Dept., Shell Oil Co., Inc., New York City, and W. E. Huddleston, Huddleston Engineering Co., Bartlesville, Okla., co-chairmen.

### Chemical Industry Symposium

F. A. Rohrman, Engineering Experiment Station, University of Colorado, Boulder, Col., chairman; W. Z. Friend, The International Nickel Co., Inc., New York City, and F. L. Whitney, Jr., Monsanto Chemical Co., St. Louis, Mo., co-chairmen.

### Fresh and Salt Water Corrosion Symposium

L. M. Mosher, Shipbuilding Div., Bethlehem Steel Corp., Quincy, Mass., chairman; J. A. Davenport, Corps of Engineers, (Continued on Next Page)



## Three TP Committee Chairmen are Changed

Chairmen of two Technical Practices committees have been changed. They are:

TP-1—Corrosion of Oil and Gas Well Production Equipment. New chairman is Ted S. Zajac, Shell Oil Co., Houston, Texas. Mr. Zajac succeeds Walter F. Rogers, resigned. Mr. Zajac has been very active as a member of this committee and the Natural Gasoline Association of America committee on Corrosion research. Mr. Rogers has nearly completed the report on work of this committee under his chairmanship.

TP-2—Galvanic Anodes. W. P. Noser of Humble Pipe Line Co., Houston, Texas has succeeded M. C. Miller of Ebasco Services, New York as chairman of this committee. Mr. Noser has been an active member of the committee since its inception in 1946.

TP-6—Protective Coatings. Kenneth Tator, Coraopolis, Pa., has succeeded Dr. George W. Seagren as chairman of this committee. The committee contemplates a survey of coating practices as outlined in Mr. Tator's proposal at the committee meeting held during the Cincinnati conference.

## Three Past Presidents

(Continued From Preceding Page)

Engineers, Cincinnati, Ohio, and A. W. Tracy, The American Brass Co., Waterbury, Conn., co-chairmen.

### Corrosion Principles Symposium

Norman Hackerman, associate professor of chemistry, University of Texas, Austin, chairman; H. H. Uhlig, associate professor of metallurgy, Massachusetts Institute of Technology, co-chairman.

### Protective Coatings Symposium

Raymond P. Devoluy, C. A. Woolsey Paint and Color Co., New York City, chairman.

### Oil and Gas Industry Symposium

E. Q. Camp, Humble Oil and Refining Co., Baytown, Texas, chairman.

### Cathodic Protection Symposium

Robert J. Kuhn, Consulting Engineer, New Orleans, La., has accepted chairmanship of the Cathodic Protection Symposium and will have as co-chairman Sidney E. Trouard, New Orleans Public Service Co., and Harold A. Robinson, The Dow Chemical Co., Midland, Mich.

F. J. McElhatton, Panhandle Eastern Pipe Line Co., Kansas City, Mo., has accepted the chairmanship of the Pipe Line Round Table.

Further announcements of chairmen are expected soon.

Otto H. Fenner, Monsanto Chemical Corp., St. Louis, Mo., has accepted the post of chairman of local arrangements for the April 3-7, 1950, NACE meeting at the New Jefferson Hotel, St. Louis, Mo.

## NACE MEMBERS

*IF You Change Addresses*

*IF You Change Company Affiliation*

*IF You Change Positions*

Please notify the Central Office NACE, 919 Milam Building, Houston 2, Texas, so that you will get CORROSION without delay and that association records can be kept abreast of your progress.

**THANKS!**

## Data to Be Collected on Corrosion Circulation

Now under consideration by the NACE executive committee and certain other officials and committee chairmen is a draft copy for a circulation data survey form to be used later this year to collect information about readers of CORROSION Magazine. The data desired is broken into two classes, one pertaining to the industry represented by the reader and the other to the kind of work the reader does.

More than 20 general headings of industries have been compiled, and about 10 job areas.

The form will be arranged with descriptive data as coordinates along two sides, with cross lines. A check made at the intersection of the lines encompassing an industry heading and those encompassing a job heading will give an index in both classifications.

Data thus collected will be reduced to a code and placed on a punch card especially designed as a record for this and other pertinent information about the association's membership and subscribers. The final form for the punch card on which the data will be coded also has yet to be determined, but the essentials are known and set.

Preliminary work on the circulation data form was done with the view of arriving at a final format which would be as easy to fill in as possible in view of the information desired. To this end, all extraneous matter has been deleted.

Information made available to the association in this way will be confidential as to individuals but will be used as the basis for statistical data.

Proceedings of the Fifth Annual Meeting of the Metal Powder Association held in Chicago in April are available now. The 116-page illustrated booklet contains seven articles on powder metallurgy and may be obtained from The Metal Powder Association, 420, Lexington Ave., New York 17, N. Y. The price per copy is \$3.

## NBS Data on Acid Pretreatment Reported

Effect of acid pretreatment of porcelain enamels has been reported by the National Bureau of Standards in Technical Report 1357, a summary of work done by J. R. Crandall of the Enamelled Metals Laboratory. The effects were noted during revision of federal specification for enameled graduates for dark-room use when tests were made to compare the relative effects of hydrochloric, acetic and citric acids on a number of enamels.

The tests indicated acetic acid was much less corrosive than hydrochloric and citric acids. The most significant finding, however, was that treatment with acetic acid which produced only minor visible attack, strongly inhibited further attack when the surface was treated with citric acid, although the citric acid severely attacked areas untreated by acetic acid.

It was found that pretreatment with acetic acid in concentrations from 0.5 to 50 percent for 5 minutes or longer were effective against subsequent treatment with citric acid. Treatment with butyric acid for 15 minutes produced the same effect, but neither tartaric nor lactic acid was effective. The passivation effect may be explained by the hypothesis that the acetic and butyric acids preferentially leach alkalis from the enamel surface, leaving behind a silica-rich film which is resistant to further solution even in citric or stronger acids.

Treatment with 10 percent citric acid for 15 minutes appreciably reduced abrasion resistance of certain enamels having Class B or Class A resistance (Porcelain Enamel Institute standard test), this effect being more pronounced on titanium-type than antimony-type enamels. The results suggest titanium-type enamels are especially sensitive to the observed effects. Sensitivity of these enamels to attack by abrasion after treatment with acid indicate that an abrasion treatment should be incorporated in the standard test for acid resistance.

Translations of 91 Russian technical articles available from Research Information Service, 509 Fifth Ave., New York 17, N. Y. are listed in Catalog No. 34, available free of charge from the translators. The current catalog, which contains abstracts of the articles available encompasses fields from aerodynamics to physics, including inorganic and organic chemistry, physical chemistry, crystallography, electron-optics, metals and metallurgy, is asserted to be a supplement to catalogs previously issued and also available.

## NEW CORPORATE AND ASSOCIATE MEMBERS

Following is a new corporate member who joined NACE during the period June 15-July 15, 1949, bringing to 271 the number of corporate and associate members.

Representative  
East Bay Municipal Utilities District, Oakland, Cal. H. A. Knudsen

## TP Questionnaires Will Clear Through Chairman

Questionnaires prepared for circulating by Technical Practices Sub-Committees should be cleared through Dr. Mars G. Fontana, chairman of the Technical Practices Committee, the National Association of Corrosion Engineers board of directors decided in Cincinnati April 15, 1949, it was reported by A. B. Campbell, executive secretary.

This procedure was considered necessary in order that activities of subcommittees be coordinated to avoid overlapping of functions and to keep the chairman of the committee abreast of the activities of the divisions of his organization.

## Committee Arranging Details of Short Course

Direction of arrangements for the corrosion short course to be held at University of Texas, Sept. 12-16 has been taken over by a committee of South Central Region NACE members headed by R. A. Brannon, of Humble Pipe Line Company. Assisting Mr. Brannon in carrying out arrangements for the course are L. R. Sheppard and A. L. Stegner.

The committee is working closely with Dr. Norman Hackerman, university faculty member, who is making most of the arrangements for the program, housing and handling other details in Austin.

## Remarks on 1949 Papers Are Being Processed

Remarks, comments and questions about papers presented at the 1949 NACE Conference in Cincinnati which have been collected by Central Office NACE are being sent to authors of papers for such replies as are indicated. A July 31 deadline for receipt of these written remarks was set (inquiry forms on which were mailed to all persons for whom correct addresses were available who were reported as having made a comment on a paper), and postcard notification sent to those from whom no reply to the inquiry form had been received.

This does not mean that further comments on these papers are not being received, but that an effort is being made to have all remarks and authors' replies to remarks published at the same time the papers are published. In the case of those papers published before the remarks were processed, publication will be made in later issues, with appropriate reference to the article.

A List of standard samples issued or in preparation by the National Bureau of Standards, is detailed in a supplement to NBS Circular 398, "Standard Samples Issued or in Preparation by the National Bureau of Standards," 19 pages, free on request, Publications Section, National Bureau of Standards, Washington 25, D. C.

## Committee of Offshore Operators is Organized

Representatives of petroleum operators owning leases in the Gulf of Mexico, operating as an informal organization known as "Offshore Operators Committee" have been active since the latter part of 1948 seeking solutions to common problems of participating organizations.

Principal activity of the committee has been discussion of Coast Guard regulations within the committee and with representatives of the Coast Guard insofar as they affect operation of vessels engaged in petroleum production.

The committee's principal objectives, besides a rationalization of regulations pertaining to shipping, include investigating the feasibility of forecasting state of sea (wave heights, directions and related phenomena) and weather and investigation of the advisability of sponsoring oceanographic research projects to determine physical and biological conditions present in the gulf and changes occurring and their causes.

Committee meetings are held quarterly or more often, if request is made by a member. All decisions are by majority vote, and individual members are not bound by committee decisions.

Mercer H. Parks, Petroleum Engineering Division, Humble Oil & Refining Co., Houston, Texas, is chairman.

## World Petroleum Meet Scheduled at The Hague

The third World Petroleum Conference has been scheduled for May or June 1951 at The Hague, Netherlands. The congress will be organized by the petroleum section of the Netherlands Royal Institute of Engineers.

Purpose of the congress is to provide an opportunity for scientific discussion of technical subjects relating to the petroleum industry.

Secretariat for the congress has been established at 30, Carel van Bylandtlaan, The Hague to which names and addresses of those who plan to attend should be sent. A circular giving full particulars will be forwarded. The congress will last one week and official language will be French and English.

Detailed Descriptions of the vacuum pan, grainer and Alberger systems for producing salt, illustrating the use of Monel and nickel to protect color and purity in salt refining are given in a free publication entitled "Salt" issued by International Nickel Co., 67 Wall Street, New York 5, N. Y.

## Corrosion Fundamentals Taught at University

Engineering students at the University of Houston are being offered a course in corrosion fundamentals. The course, essentially elementary in scope, includes studies of electrochemistry, oxidation and reduction. It is a required subject for undergraduate chemical engineers and is open to all other interested engineering students as an elective.

The term ending in July had sixteen students under instruction of Associate Professor John P. Roberts. Professor Roberts, an NACE member, arranged field trips as a practical background for classroom work to Dixie Electro Plating, Houston Port Commission, Houston Light and Power Company and Shell Pipe Line Co., all in Houston.

## PERSONALS

Marcel Pourbaix of the University of Brussels, Belgium, is visiting for two months at University of Oregon, Eugene, as an Advanced Fellow of the Belgium-American Educational Foundation. He will work in the chemistry department in preparation of potential pH diagrams. The method of graphic representation originated by Dr. Pourbaix has many uses, particularly in the field of corrosion.

Sidney Sussman has become associated with Water Service Laboratories, Inc. of New York as chief chemist. Dr. Sussman was chief chemist for Liquid Conditioning Corp. and held various positions in the Permutit Co. His achievements include contributions to the development of the seawater desalting process. Water Service Laboratories specializes in corrosion prevention services in air conditioning systems and boilers and piping systems.

Edward P. Noppel, chairman of NACE Planning and Policy Committee, has been named a vice-president of Ebasco Services, Inc., T. C. Wescott, president, says. He has been a director of the company since 1942 and has been associated with Electric Bond and Share Co. and its subsidiary, Ebasco Services, Inc., since 1925.

R. W. Capaul has been named general sales manager of Glass Fibers, Inc., Waterville, Ohio. He had been manager of the electrical division, F. J. Solon, Jr., has been named director of advertising and public relations.

J. F. Byers, Sr., chairman of the board of J. M. Byers Co., Pittsburgh, died June 11 at Roosevelt Hospital, New York City.

W. J. Berry has been named pipe line service engineer by Dearborn Chemical Co., manufacturers of No-Ox-Id coatings. He will make his headquarters in Chicago but will devote his time exclusively to field work on pipe line construction projects.

# NEW PRODUCTS—Materials—Service—Literature

**Sturgis Products Co.**, Sturgis Michigan, producer of mechanical finishing equipment, has changed its name to Roto-Finish Co. and moved to Kalamazoo, Mich.

**S. G. Taylor Chain Co.**, Hammond, Ind., offers a 12-page bulletin listing and specifications on alloy steel chain. Copies are available without charge.

**Saran 187-Lined steel pipe** from 8 to 36 inches inclusive, with Saran-lined fittings to match now is being fabricated by Michigan Pipe Co., Bay City, Mich.

**High Strength** and resistance to abrasion and corrosion are claimed for several high-strength industrial ceramic materials made by Coors Porcelain Co., Golden, Col. The parts, made to close tolerances and with finishes for specific services, are machined before final hardening, which is effected to close tolerance, the manufacturers say. Physical properties vary with type, but Al Alumina has a tensile strength of 25,000 psi, compressive strength 290,000 psi, expansion coefficient about half that of steel, specific gravity of 3.63, and hardness comparable to natural sapphire. Friction coefficient is low for all types, elasticity modulus greater than that of cast iron. More information about these materials may be obtained from Coors Division, Landes, Zachary and Peterson, 272 S. Santa Fe Drive, Denver 9, Col. Design engineering service is available.

**"Vibrotest"** an insulation-resistance measurement instrument made by Associated Research, Inc., 3758 West Belmont Ave., Chicago 18, Ill. is described in a 4-page bulletin No. 209 which lists capacities and specifications for all models from 100 to 50,000 megohms.

**Cooper Alloy Comparison Chart**, Stainless Steel 2-inch Alloy Gate Valves, compares the size and specifications of Cooper valves to others. Copies of the chart are available on request from The Cooper Alloy Foundry Co., Hillside, N. J.

**Line Material Co.** has moved its Dallas office and warehouse to 107 Pittsburg Street, Dallas 2, Texas.

**"Carbo-Flex,"** a thermosetting plastic manufactured by the Carbolite Co., 7603 Forsythe Blvd., St. Louis 5, Mo., is recommended by the manufacturers for application to surfaces where resistance to acids, alkalis and solvents at temperatures as high as 325° F. and resistance to foot traffic, is necessary. The material consists of a liquid and a powder which when mixed has a mortar-like consistency and is applied with a trowel. It can be applied to vertical surfaces in layers of about 1/16-inch without sagging. When set the manufacturers claim it is hard, waterproof and impervious to most corrosives and solvents except nitric acid and sulfuric acid over 45 percent. Flexibility claimed for the materials is from 7 to 15 percent. Compression strength is 10,000 lb. sq. in.

**"Electrodip"** an aluminum dip tank or melting pot, thermostatically controlled has an aluminum casting dip-compartment designed for maximum usefulness in dipping ethyl cellulose and other removable plastics or as an oil bath heater. Temperatures set on the calibrated dial are held within 1° F. Heating elements are 1000 watts and range is 60 to 250° F. or 200 to 500° F. It is manufactured by the H. McNaughton Co., 201 Parsons St., Kalamazoo, Mich.

**Centrifugal Cast iron pipe** now is being produced by the Pacific States Cast Iron Pipe Co., Provo, Utah on three deLavaud machines. Capacity of the plant, said by F. H. McGraw & Co., New York engineers and constructors, to be the only one west of the Mississippi, is 100,000 tons a year. Special equipment designed by the McWane Cast Iron Pipe Co., Birmingham, Ala. parent firm, dips the pipe in tar before shipment. Additional facilities are being provided for lining pipe for special conditions with a thin coat of cement.

**American Vacuum Seam Tester**, a device for quickly locating leaks in pipes, tanks or other storage vessels often can be used without taking the unit out of service. It also is useful in testing perfection of welds and seams in new construction. It consists essentially of a chamber faced with transparent glass on one exposure with an open end ringed with soft rubber. Seams to be tested are covered with soap suds, the testing box is placed over the area, a powerful vacuum within the testing box draws air through the soap suds, causing bubbles to form. The testers are made in a wide variety of sizes and shapes for inside corners, outside corners, circumferential seams and straight seams by American Pipe and Steel Corp., 2201 West Commonwealth Ave., Alhambra, Cal.

**Up to 500 tons** a month of stainless steel wire ranging in gauges from 1/2 inch to .004 inch and less is the capacity of a new stainless steel wire drawing plant of American Steel and Wire Company at Waukegan, Ill., a subsidiary of United States Steel.

**Construction and packing materials** for use with over 300 industrial liquids and gases are listed in Revised Catalog Section 97 published by Fischer and Porter Co., 97 County Line Road, Hatboro, Pa. The tabulation of corrosion-resistant materials is based on published data, supplemented by the company's experience in handling corrosive fluids. Copies are available.

**More Than 10 tons** of alloy steel castings were made by Lebanon Steel Foundry, Lebanon, Pa., for American Car and Foundry Company's ACF-Talgo Super trains. The Talgo train, invented by a Spanish engineer, consists of 20-foot coach sections with two wheels at one end, with the other resting on the car ahead. The train is said to be 75 percent lighter, floors three feet closer to roadbed and nearly four feet less in overall height than standard trains.

**Precision Scientific Company**, 3737 W. Courtland St., Chicago 47, Ill., will mail on request copies of its 32-page catalog 860NR illustrating and describing its line of laboratory apparatus and accessories for preparation of metallographic specimens.

**Maintenance of Industrial instruments** will be the order of business for a 3-day clinic scheduled by the Instrument Society of America, September 9-12 in the Statler Hotel, St. Louis, Mo.

**Tube Turns Inc.**, Los Angeles branch office has been moved to General Petroleum Bldg., 612 South Flower Street, Los Angeles.

**Relaxation Tests** at temperatures up to 1800° F. can be carried out automatically with a record of the decline of load by means of a new machine of 4000-pound capacity announced by The Baldwin Locomotive Works, Philadelphia, Pa. The machine automatically relaxes tensional loads from as high as 40,000 psi., permitting strain increments of only 2x10<sup>-6</sup> inch-per-inch of the 6-inch gauge length of a standard 0.356-inch specimen. Accuracy is approximately 1 percent of load or .25 percent of capacity. The recorder produces a curve of stress vs time on a flat chart.

**Tapecoat** in 18 and 24-inch widths now is being manufactured by The Tapecoat Company, Evanston, Ill. The additional widths round out the company's line of protective coatings in tape form A. W. Bohne, general manager says, adding that these new widths give Tapecoat a utility range that will serve practically any protective coating requirement in the field. The new widths are adapted particularly for large diameter pipe joints, protection of large bends, wrapping mechanical couplings and patching transmission lines.

**Automatic Dehumidification** of components of the navy's "mothball fleet" is provided by a system incorporating a 3-inch electric fan which circulates air within the space to be dehumidified over vapor-absorbing silica jelly until the humidity has been reduced to 30 percent or less, according to Sturtevant Division, Westinghouse, Hyde Park, Boston, Mass. The system also dries the silica jelly with heated outside air when it has become saturated.

**Electro-Chemical Supply and Engineering Co.**, of Paoli, Pa. which has been active in the acid and corrosion-proofing fields for many years, has been completely reorganized. A new plant with 16,000 square feet of floor space is being fully equipped at Emmaus (Allentown) Pa. Officers are Dr. C. R. Pavne, president; J. Wm. Grant, vice-president and sales manager; Wm. a Seshier, treasurer and production manager and Walter L. Sheppard, Jr., advertising manager and export sales manager. The company was an early manufacturer of acid-proof cements and a pioneer in engineering acid-proof construction.





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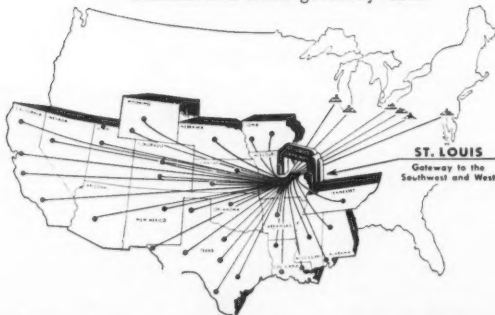
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## BOOK REVIEWS

**PRINCIPLES OF MAGNAFLUX**, by F. B. Doane and C. E. Betz. Third Edition, 388 pages, cloth cover. Publishers, Photopress, Inc., Chicago, Ill. Available from Magnaflux Corp., 5900 Northwest Highway, Chicago 31, Ill. Per Copy, \$5. An extensive revision of this book on magnetic particle inspection.

The following publications of the National Bureau of Standards are available:

**RP1949**—Weather Resistance of Porcelain Enamels exposed for Seven Years. 14 pp, 10 cents. Report on a seven-year study of weather resistance of porcelain-enamelled architectural panels.

**R217-49**—Copper Water Tube and Copper and Brass Pipe (Supersedes R217-46) 10 pp, 10 cents. A schedule of specifications.

A New Laboratory area and an enlarged electrical engineering staff at Batelle Institute, Columbus, Ohio, have made possible an expanded program of research in electrical engineering, Director Clyde Williams has announced. Batelle studies in this field will include electrical machines, instruments, X-rays, electromagnetic fields, materials testing and others.

**Sines and Cosines** with decimal subdivisions sufficient for interpolation to 15 decimal places are available in National Bureau of Standards Publication AMS 5 "Tables of Sines and Cosines to Fifteen Decimal Places at Hundredths of a Degree," 95 pages, 40 cents a copy, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Remittances from foreign countries must be made in United States exchange and include an additional sum of one-third the publication price to cover mailing costs.

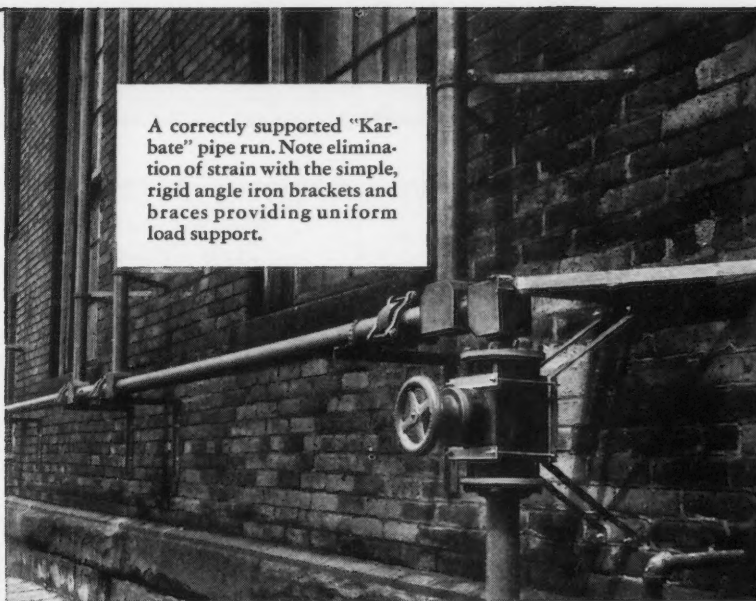
"Inter-Weld," a process for mechanical gold plating developed by the Gold Filled division of American Silver Co., Flushing, N. Y., consists of welding a gold layer to a barrier layer of nickel and soldering the composite to the base metal in the conventional manner. This method overcomes the principal objection to soldering mechanically plated carat gold rolled down to thicknesses approaching gold electroplate—the tendency of the silver solder to "bleed" through the gold, the manufacturers claim. The gold-filled and gold-rolled plate can be furnished with bases of brass, nickel silver, nickel, Monel, cupro-nickel or beryllium copper.

**Ceilmate Company**, Rockefeller Bldg., Cleveland, Ohio, has issued a technical data sheet giving recommended uses and test data on Ceilmate resin cement. Agents to which the coating is resistant and those for which it is not recommended are listed.

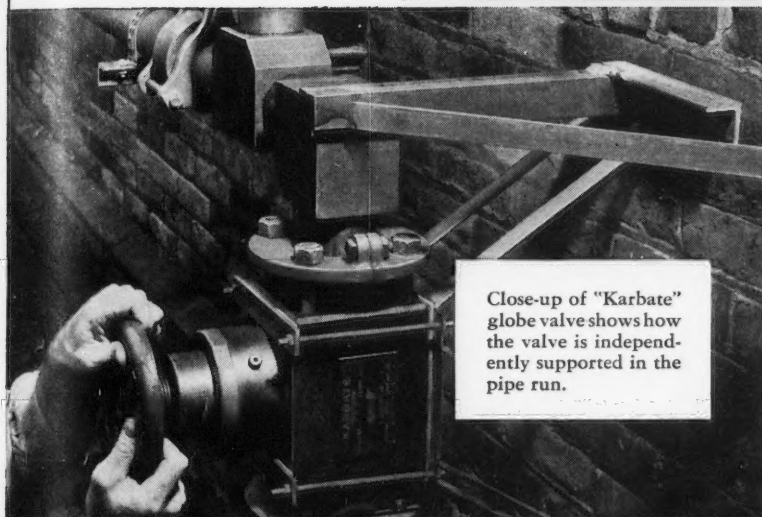
**Seismic Service & Supplies**, 131 Harvard St., Houston, Texas, is offering a portable rotary drill rig weighing less than 1000 pounds which is capable of drilling a 5-inch hole to more than 200 feet. It requires a driller and helper to operate.

# How to support a "Karbate" pipe line.

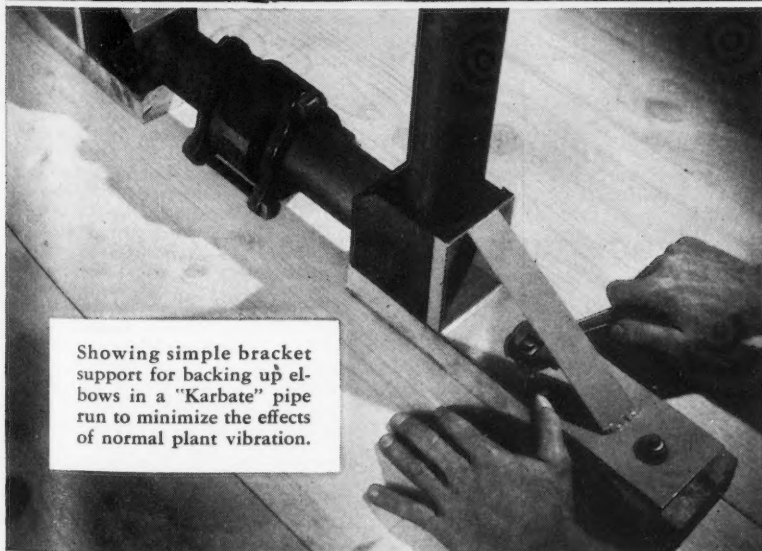
A correctly supported "Karbate" pipe run. Note elimination of strain with the simple, rigid angle iron brackets and braces providing uniform load support.



Close-up of "Karbate" globe valve shows how the valve is independently supported in the pipe run.



Showing simple bracket support for backing up elbows in a "Karbate" pipe run to minimize the effects of normal plant vibration.



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# Corrosion Abstracts

## ATMOSPHERIC

**The Importance of Controlled Humidity in Long Time Preservation.** GEORGE C. WELLS. *Corrosion and Material Protection*, 5, 4-8 (1948) Sept.-Oct.

Describes dehumidification systems used by the Navy in preservation of the "mothball fleet." Illustrations show comparative appearances of metals, fabrics, etc. after three years exposure to 30° and 90° humidities. Maintenance of 30° humidity is sufficient to keep most equipment in very good condition.—BLR.

**Mutineers' Haven Is Now a Testing Ground for Better Pots and Pans.** *Wall Street J.* 1 (1948) Oct. 5.

In addition to the exposure station at Pitcairn Island, the Aluminum Company of America have testing stations located at Georgetown, British Guiana; La Jolla and San Francisco, California; Miami, Florida; St. Louis, Missouri; Point Judith, Rhode Island; Edgewater and Sandy Hook, New Jersey; State College and New Kensington, Pennsylvania. Aluminum samples are made up into small panels, or test specimens. After being exposed for various periods of time, they are returned to the company's laboratories at New Kensington to be examined.—ALL.

**Report No. 10 of the Sub-Tropical Test Station, Tahiti Beach, Florida, Centro Research Laboratories.** U. S. Bur. Ordnance (Navy Dept.) Contract NORD 6119; *Prev. Det. Abs.*, 4, M 15-17 (1948).

Abstracts of reports of fungicidal tests on paints, varnishes, lacquers, waxes, cork, leather, glass laminates, etc.; only a few fungicides are named. Of these, phenyl-mercuric-o-benzoic sulphimide in binders for glass laminates (concn. not stated) 2, 2'-methylene-bis-(4-chlorophenol) in cardboard (3%) and a salicylanilide (5-10%) and salicylanilide (5%) + phenylmethionyl-o-aminophenyl-mercuric thioether (0.5%) or phenyl-mercuric-o-benzoic sulphimide (0.5%) in a short tung oil varnish, were effective under tropical conditions.—RPI.

**The Motor-Car vs. the Weather.** H. SILMAN. *J. Electrodepositors Tech. Soc.*, 23, 121-138 (1948).

Survey of the various methods for protection of metal surfaces in motor-car parts.—BNF.

**Low-Alloy High-Strength Steels Surpass Copper Steels for Corrosion Resistance.** C. P. LARRABEE. (Carnegie-Illinois Steel Corp.) Paper before ASM, Indianapolis Chapter, March, 1948. *Metals*, 5, 35 (1948) May 21.

Evidence that increased corrosion resistance is a feature of low-alloy high-strength steels which are now preferred in many applications where plain carbon or copper-bearing steels were formerly specified is given. Corrosion data collected from as early as 1912 was correlated. In one method of conducting

## Abstract Section Style Outlined

For ease in locating reference data, CORROSION uses a uniform style in its Abstract Section.

The abstracts first are broken down into major classifications of the more common types of corrosion literature. In each review the title of the article is presented in bold face type, followed by the author's name. The publication from which the article was abstracted is printed in italics and is abbreviated in most instances. Following this, in sequence, are the volume (bold face), number in the volume, pages, year and month of publication. In some instances a second reference will be listed in the same manner. This indicates that the article also was published or abstracted in another publication. A brief summary of the article follows the above information and it is concluded with an abbreviation indicating the source of the abstract and contributor. The meanings of these abbreviations usually are listed on the first page of the Abstract Section.

When seeking more detailed data about an abstract, best source of information is the publication in which the article appeared originally. (Listed in italics in the heading.) The contributor of the abstract also may be able to supply additional information. Addresses of most of these publications may be found in the reference section of most public libraries.

tests a number of specimens were weighed, exposed, removed from the holding racks, cleaned of rust, and reweighed. Over a period of years, time-corrosion curves were drawn based on the loss of weight. Corrosion resistance of structural steels varied so widely with conditions of exposure that exact numerical standards of comparison are impossible between different steels. Uncoated copper steels have from 1.5-3.5 times the resistance of steels containing only resid-

ual copper, when subjected to atmospheric attack. Low-alloy high-strength steels resist from 4-6 times as long as plain steel, and from 2-3 times as long as Cu steels. In the high-strength alloys, a finer grained, more adhering, protective rust coating is formed, which contributes to their resistance. These steels are superior to plain steel or copper steel when painted or galvanized. Steels containing 2% or more of chromium are best for sea water resistance. Only application cited where they have failed to justify their increased cost is for underground use.—INCO.

**The Atmospheric Corrosion of Iron and Steel Wires.** J. C. HUDSON. *J. Iron & Steel Inst.*, 160, 276-285 (1948) Nov.

Results of tests on the corrosion of ferrous wires when exposed in an industrial atmosphere for periods of up to 10 years are reported. The rate did not vary appreciably with duration of exposure, but was greater for thin than for thick wires. Certain wrought irons and low-alloy steels proved much more resistant than mild steel. Practical applications of these observations are discussed.—BLR.

## BEARING

**The Engine Performance of Lubricants.** C. G. WILLIAMS. *Inst. of Pet. Rev.*, 2, 306-316 (1948) Oct.

Deals mainly with engine deposits and corrosion. Illustrated.—BLR.

**Bearing Corrosion in Turbo-Generators.** J. A. TEN BROEKE. *Corrosion*, 4, 590-596 (1948) Dec., discussion 597-598.

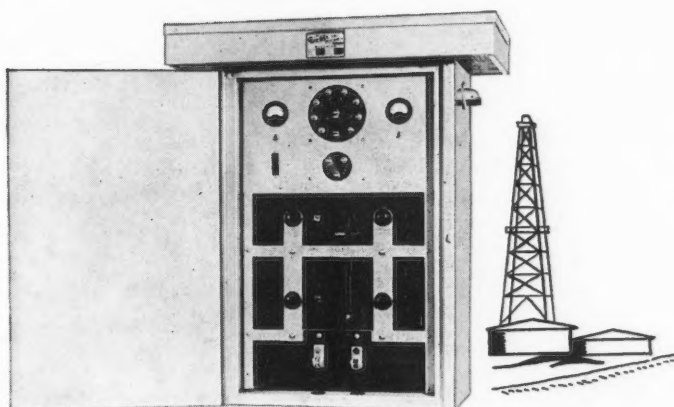
Describes and illustrates several cases in which stray currents and electrostatic charges caused above type of corrosion.—BLR.

Abbreviations at the end of abstracts indicate source of abstract and contributor; and are as follows:

AER	Aeronautical Review, Institute of Aeronautical Sciences, Inc.
ALL	The Abstract Bulletin, Aluminum Laboratories, Ltd.
AWWA	Journal, American Water Works Association
BLR	Battelle Library Review, Battelle Memorial Institute Library
BNF	Bulletin; British Non-Ferrous Research Association
CALCO	Calco Chemical Division, American Cyanamid Corp.
CE	Chemical Engineering, McGraw Hill Publishing Co.
CEC	Consolidated Edison Co. of New York, Inc.
EW	Electrical World, McGraw Hill Publishing Co.
GPC	General Petroleum Corp. of California
INCO	The International Nickel Co., Inc.
IP	Institute of Petroleum
MA	Metallurgical Abstracts, Institute of Metals, London, Eng.
ME	Marine Engineering
MR	Metals Review, American Society of Metals
NALCO	National Aluminate Corp.
NBS	National Bureau of Standards
RA	Refrigeration Abstracts, American Society of Refrigeration Engineers
RM	Revue de Metallurgie, Paris, France
RPI	Review of Current Literature Relating to the Paint, Colour, Varnish & Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London.
TDD	Technical Data Digest, Air Materiel Command—Technical Service Section
UOP	Universal Oil Products
No Code	Current Technical Literature, Bell Telephone Laboratories



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**A Visual Rating System for Rusted Steel Specimens.** HARRY L. FAIGEN. *ASTM Bull.* (1948) 39-44 Oct.

A convenient system for rating rusted steel surfaces visually is outlined and illustrated. Numbers and letters are employed to designate stages of rusting as defined by verbal descriptions or pictorial representation in a logical and easily remembered succession of steps.—BLR.

**Indium Plated Lead Bearings Withstand High Stresses.** JOSEPH ALBIN. *Matl. and Meth.*, 27, 6, 88-89 (1948) June.

The addition of indium to lead platings and its subsequent diffusion into an underlying coat makes bearing surfaces harder, tougher, and more resistant to corrosion by lubricants. Bronze bearings treated with silver-lead-indium coatings have been made to resist bearing pressures over 10,000 psi. Although most aviation bearings are of the silver-lead-indium type, indium can be plated and diffused on copper, cadmium, zinc and tin.

The control and specifications of lead-indium plating are very rigid. Four types of baths are employed commercially. One bath, a solution type, uses indium cyanide at room temperature; the current density is 15-20 amp. per sq. ft. and minimum sludging is obtained when the anode is plain steel. The cathode efficiency is about 75% and the throwing power is excellent. The other three types of baths require indium anodes for replenishment. The first is a sulfate bath containing about 2.5 oz. indium and about 3.25 oz. sodium sulfate per gallon and has a pH between 2-2.5 and a current of 20 amp. per sq. ft. The second is an indium fluoborate bath having a pH below 0.2 and operating at a temperature of 75-90° F. and a current density of 100 amp. per sq. ft.; an excess of fluoboric acid insures stability. The third, a sulfamate bath, contains 2.5 oz. of indium metal per gallon; the current density if as high as in any of the other baths and is not critical.

After plating, the indium is diffused into the base of the metal by heating for 2 hours at about 350° F. slightly above the melting point of the indium. The amount of indium does not exceed 5 mg. per sq. in. and the thickness of the undercoating will vary from a few ten thousandths to one-two thousandths of an inch.—Illus.—DPA.

## CATHODIC PROTECTION

**The Use of Zinc for Cathodic Protection (of Steel).** H. H. WAHLQUIST and E. A. ANDERSON. *Metals Handbook* (Am. Soc. Metals) 1084-1085 (1948).

The protection of underground pipes, hulls of ships, and boiler plates by the use of zinc anodes is described, details of the method of installation being given in each case.—MA.

**Active Iron in Alkaline Solutions** (In French). GUSTAV NILSSON. *Metall & Corrosion*, 23, 206-211 (1948) Sept.

It was found that, under certain conditions, cathodic treatment facilitates rather than prevents corrosion. Activity of iron in alkaline solutions was demonstrated by means of specific organic and

inorganic agents. Method of investigation is indicated; data are tabulated. 19 ref.—BLR.

**Magnesium for Cathodic Protection.** *Metal Prog.*, 54, No. 2, 224-228 (1948).

Summary of the paper "The Cathodic Protection of Steel in Sea Water with Magnesium Anodes" by H. A. Humble, presented before the National Association of Corrosion Engineers, April, 1948. The paper consists of two parts, the first of which deals with the anodic performance of magnesium and some of its alloys, while the second part is concerned with the effects of various initial and continuous c.d.—MA.

**Cathodic Protection.** *Heating & Ventilating*, 45, No. 8, 122 (1948) Aug.

Cathodic protection of underground metallic structures was effective in 6-yr. tests completed at Nat. Bur. of Standards. Corrosion of steel specimens was prevented by connecting zinc cylinders to the steel. Discussion of cause of corrosion, means of protection, test results and exhibit of the 3,000 test specimens, consisting of 85 varieties of materials, including cast iron and cast alloys, steel and steel alloys, copper and copper alloys and miscellaneous samples.—INCO.

## COATINGS

**Aluminum Spray Coating to Protect Welded (Steel) Units.** MERRIL A. SCHEIL. *Metal Prog.*, 54, No. 1, 64 (1948).

When pressure vessels have to be protected against rusting, sprayed aluminum (0.003-0.005 in. thick) is superior to plastic coatings because it can be applied before stress-annealing treatment.—MA.

**Pipe Lines for Corrosive Liquids.** J. RINSE. *Chem. Weekblad*, 43, 780-1 (1947); *Brit. Abstracts*, B-1, 355 (1948).

Iron pipes are coated on the inside with a poly-vinylchloride resin, and dried. The pipes, after fixing, are heated, e.g., by induction currents, while pressure is applied to force the resin lining on to the inner metal surface. The joints are made with vinyl resin packing. Such pipes are stable to acids, bases, soaps and solvents to 90° F. and are comparable in price with pipes of Pyrex glass.—RPI.

**Priming Paints for Light Alloys.** J. G. RIGG and F. W. SKERRY. *J. Inst. Metals*, 75, 69-80 (1948) Oct.

The protection afforded to aluminum and magnesium alloys by various paint primers is being investigated in rural, industrial and marine atmospheres. Results have so far shown that iron oxide primers provide useful protection, whereas red lead primers are definitely harmful on aluminum, and especially so on magnesium. Primers pigmented with zinc chromate and zinc tetroxychromate are providing most efficient protection to light alloys.—BLR.

**Deterioration Research Laboratory.** E. S. REYNOLDS. *Paint Varnish Prod. Mgr.*, 28, No. 10, 302-6 (1948).

A general account is given of the work of the research and testing station of the University of Miami set up to investigate mould growth under tropical and sub-tropical conditions. More useful re-

sults are obtained by subjecting test materials to general mould infection over a varying natural (tropical) temperature cycle than by exposure to specific organisms at controlled temperature and humidity. The specificity of the fungus fungicide system is stressed.—RPI.

**Fungus Growth on Paint Surfaces.** E. S. REYNOLDS. *Science News Letter*, 54, No. 15, 230 (1948).

A short report of work done in America to isolate, identify and test mould growth on paint test panels. The mould was found to be *Pullularia*, and to be less easily discouraged by fungicides than several other common moulds.—RPI.

**Coating for Steel.** *Rev. Sci. Instruments*, 19, No. 4, 280 (1948) April.

Banox, dry granular material, dissolves in water for spraying on clean steel surfaces to protect against corrosion and to form a base for painting or enameling. Mfd. by Calgon, Inc.—INCO.

**The Properties of Sprayed Metal Coatings.** (In German.) H. REININGER. *Metalloberfläche, Part I* (G), 2, No. 9, 10, 185-192, 213-218 (1948) Sept., Oct.

A survey of the effect of different variables on density of coating, gas content, soundness (a measure of the time taken for gas to diffuse through the coating), porosity, strength, adhesion, hardness and corrosion resistance of coatings of various metals sprayed by powder and wire processes.—BNF.

**Organic Poisons and Organo-Metal Compounds for Anti-Fouling Paints.** H. RABATE. *Peintures, Pigments, Vernis*, 24, No. 9, 275-8 (1948).

A review. Many effective poisons are mentioned, together with the organisms against which they may be used. The future of anti-fouling paints is discussed.—RPI.

**Corrosion Preventive.** ANON. *Prod. Fin.*, 1, No. 4, 74 (1948).

A coating composed of polyvinyl butyral resin and phosphoric acid is used as a wash primer under anti-corrosive paints or as a temporary protection before painting. It is claimed to have corrosion-resisting properties.—RPI.

**Selecting Protective Finishes for Springs.** RONALD F. POND. *Machine Design*, 20, 128-132 (1948) Dec.

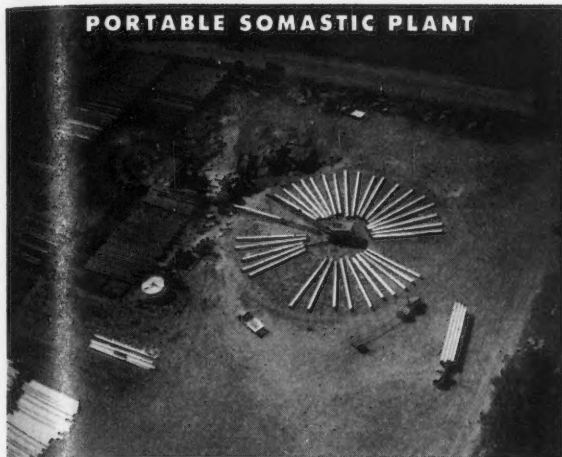
Discusses factors involved including appearance, protection vs. corrosion and abrasion, kind of material in the spring, surface characteristics of material to be finished, deflection required, size of springs, and proportions of springs. Emphasis is on plating, although other finishes are also mentioned.—BLR.

**Protection of Metallic Surfaces by "Araldite" Synthetic Resin** (F). G. H. OTT. *Metall & Corrosion*, 23, No. 270, 41-46 (1948) Feb.

The Araldite group of thermosetting resins has been developed by the C.I.B.A. company of Switzerland, and applications to the joining of light metals have already been described. The present article describes properties and uses of "Araldite 985" as a protective coating. It is said to be hard, adherent, elastic and resistant to many chemicals; it can be used, for instance, to protect aluminum cans and toothpaste tubes.—BNF.

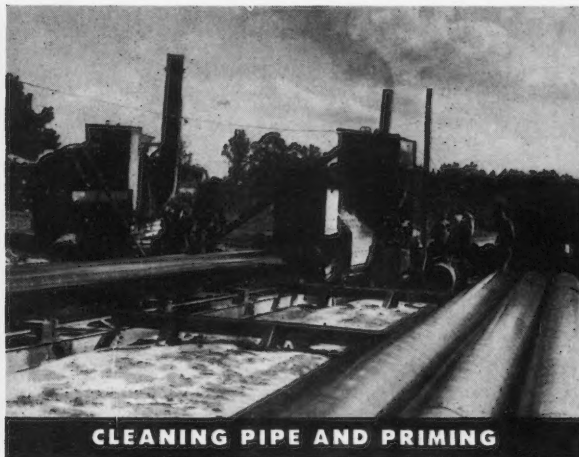
# PROTECTION AND *Permanence*

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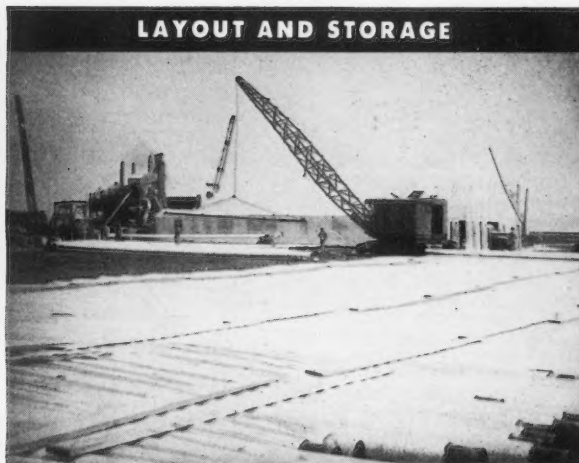
**RAILHEAD PLANT**—In customer's area. General view of equipment layout showing compactness of coating operations.

## CLEANING PIPE AND PRIMING



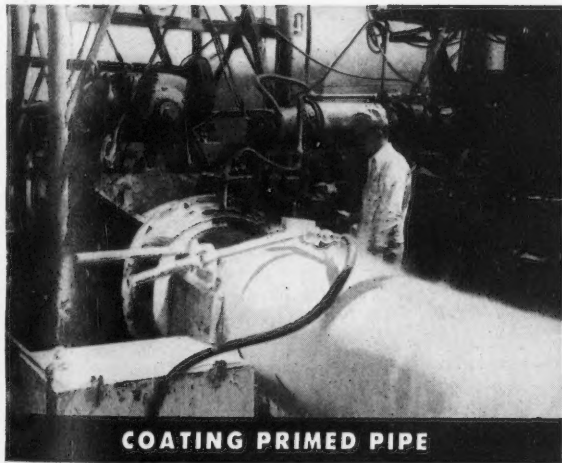
**INITIAL OPERATION**—To insure a firm bond of coating to steel, pipe is thoroughly cleaned, grit-blasted and primed with SOMASTIC Pipe Coating Primer prior to coating.

## LAYOUT AND STORAGE



**COOLING AREA**—And finished storage pile of coated pipe awaiting transportation to customer's pipe line.

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**Discussion on Anti-Fouling Compositions and Cementiferous Paints.** Iron and Steel Institute and British Iron and Steel Research Assoc. *Oil Colour Trades J.*, 114, No. 2595, 83-5 (1948).

A report of a discussion on anti-fouling and anti-corrosion tests carried out at Millport, with special reference to cementiferous paints.—RPI.

**Examination of the Resistance to Corrosion of Lacquered Transport Barrels for Alcohol.** KOHLE & EISENFORSCHUNG. Off. Tech. Serv., PB. 73426, Frames 135-141; Board of Trade, Ger. Div. (Docs. Unit), FDX 94.

A series of lacquered barrels were examined for resistance to corrosion. With three coats of varnish inside, the barrels were unobjectionable after a period of 1½ years. It is intended to extend the tests to a period of 2½ years.—RPI.

**Test of a Highly Heat-Resisting Protective Paint for Steel Plates.** KOHLE & EISENFORSCHUNG, G.m.b.H. Off. Tech. Serv., P.B. 73426, Frames 379-80; Board of Trade, Ger. Div. (Docs. Unit) FDX 94.

A highly heat-resisting paint of Herberts, Wuppertal, proved to be resistant to a gaseous mixture of CO<sub>2</sub>, SO<sub>2</sub> and steam at the temperatures used but not in the presence of water drops.—RPI.

**Painting Diversified Metal Products.** K. E. WILLIAMS. *Ind. Fin.*, 24, No. 6, 43-44 (1948).

The article explains the surface treatment before painting and the technique of applying different finishes to metal objects of various sizes, shapes and types of metal.—RPI.

**Corrosion of Iron Under Protective Coatings.** (In German.) J. K. WIRTH. *Arch. Metallkunde*, 1, 445-448 (1947) Oct.

Thorough investigations indicate that electrolytic solution pressure, electro-osmotic forces and paint-film porosity are the factors affecting the corrosion of iron. Diagrams illustrate the principle of electro-osmotic corrosion and photographs show its destructive effect.—BLR.

**The Corrosion of Iron Under Protective Films.** (In German.) J. K. WIRTH. *Arch. Metallkunde*, 1, 452-454 (1947) Oct.

Tries to explain experimentally why the electrolytic solution pressure causes corrosion as well as passivation. Among the many determining factors are electro-osmotic forces, paint porosity, tiny electrical fields in the boundary plane, electrically charged, capillary, oily-pigment mixtures. Diagrams and microphotographs illustrate the discussion.—BLR.

**The Formation of Copper Films on Non-Conductors: a survey.** SAMUEL WEIN. *Metal Fin.*, 46, No. 8, 58-60, 69 (1948).

Describes a method of producing copper films which, it is claimed, is dependable and inexpensive. The surface is first treated with an acidified solution of tin chloride, followed by treatment in a sensitizer, which is a solution of 30 grains of gold chloride in 50 ml. water. The coppering solution is made in two parts, one containing: copper sulphate 53 g., nickel chloride 16 g., and formaldehyde 200 ml.; and the other: sodium hydroxide 40 g., Rochelle salt 173 g., and sodium carbonate 16 g. The two are mixed immediately before use. Full de-

tails for the preparation of the surface and the formation of the deposit are given. The literature on the subject is reviewed and 17 references are given.—MA.

**Rapid Testing of Paints for Rust-Protective Properties.** J. VAN LOON. *Verf-kroniek*, 21, No. 8, 182-5 (1948).

Accelerated tests fall into 3 groups in which (1) corrosive conditions are kept normal but the protective coating is modified, e.g. by the use of thin films, (2) corrosive factors, e.g. light, heat and water, are intensified, and (3) corrosive factors are kept normal but compressed into a smaller time cycle. Precautions necessary in each class of tests are discussed.—RPI.

**Anti-Fouling.** J. F. H. VAN EIJNSBERGEN. *Paint Technology*, 13, No. 151, 268 (1948).

In the 18th century, barbasco, made from Jaquinia roots, was used as an anti-fouling composition. It is suggested that natural compounds of this type might well be used instead of some synthetic products on the score of equal efficiency and greater cheapness.—RPF.

**How To Prevent Iron From Rusting.** ANON. *Tin. Printer* 17 (1948) July 16; *Prod. Fin.*, 1, No. 5, 68 (1948).

The causes of corrosion are discussed, together with protective methods, for proofing against outdoor exposure. N. C. Laquers and Electro-deposition or "dipping" application of corrosion-resisting material on the surface are mentioned.—RPF.

**Spray-Application Technique.** H. J. TESTRO. *Prod. Fin.*, 1, No. 4, 54-58 (1948).

The fundamentals of the application of organic finishes using a spray gun are described.—MA.

**Electrolytic Polishing.** JOHANNES SPRINGER. *Metalloberfläche*, 1, No. 4, 81-83 (1947).

The advantages and disadvantages of electrolytic polishing are discussed. A table is given showing the electrolyte composition, c.d. voltage, time, and temperature for the polishing of steels, nickel, cobalt, copper, brasses, bronzes, zinc, tin, lead, aluminum and its alloys, and tungsten.—MA.

**Untersuchung des Verhaltens von Blanken und Eloxierten Al-Mg 3—Proben Gegenüber Verschiedenen Lacken Sowie Prüfung der Lackierten Proben auf Korrosionsbeständigkeit Gegenüber kalk- und Zementmörtel (Behavior of Polished and Anodized Al-Mg 3 alloy Samples toward Different Lacquers. Corrosion Resistance of the Lacquered Samples against Plaster and Cement).** Vereinigte Aluminium-Werke A. G., Lautawerk, Lausitz, Ger. (Reschke, J. L. and Schubert, ?). Office of Scientific and Industrial Development PB-70018, Frames 9901-9911 (1941) Sept.

The three following insulating lacquers were tested on samples of bright-rolled AlMg3 (Sisal S 53), both untreated and anodized, to determine whether they could successfully replace bitumen paints.

Lacquer	pH	Color
Kronengrund (crown primer)	4.0	brown-yellow
Holzgrund (wood primer)...	3.7	brown-yellow
Perlgrund (pearl primer)....	5.1	brown-black

Lime mortar attacked the lacquers only slightly, whereas an untreated control sheet was moderately corroded. The lacquers were generally more resistant on anodized surfaces than on the untreated. On a treated surface a two-coat film of Perlgrund was unaffected, but the other two lacquers showed blister formation. On untreated samples, the top layer of Perlgrund was damaged, but the second layer was not; both layers of the other two lacquers and the metal surface were attacked. A four-coat film on untreated samples was more protective. Samples of Kronengrund were unchanged, and the other two lost part of their top layer.

Cement mortar was more corrosive than the lime mortar. All two-coat films on anodized as well as on untreated sheets were attacked and the lacquers, especially Perlgrund were almost completely scaled off. The metal surfaces were also moderately corroded. A four-coat film gave little improvement in corrosion protection even though adhesion of the lacquers on the anodized base was better. An untreated control sample was attacked fairly strongly. Samples embedded halfway in the mortar did not show increased corrosion attack at the mortar-air boundary. The corrosive effect of the lacquers upon the substrate was evaluated visually and by weight loss measurements. Untreated sheets were slightly or moderately pitted, anodized layers were unattacked after 30 days and only partly discolored by a slight absorption of lacquer; anodized coatings impregnated with I. G. Wax were unchanged.

The lime mortar consisted of 1 part lime to 3 parts sand, the cement mortar of 3 parts cement to 1 part sand. The test period of 30 days was too short for results to have practical significance.—DPA.

**Formulation of Corrosion Resistant Paint.** JOHN W. NEE. *Corrosion*, 4, 599-611 (1948) Dec.

Presents general discussion of the above. Considers properties and applications of phenolic resins, coumarone-indene resins, vinyl resins, chlorinated rubber, and specialty resins (synthetic rubber derivatives) for such use. Also discusses a few of the pigments used in formulating primers for exposure under suitable top coats in corrosive areas. Includes a few test-panel photographs.—BLR.

**Plastic Coatings and Corrosion.** C. G. MUNGER. *Corrosion*, 4, 557-565 (1948) Nov.

Describes the various types of plastic coatings for metals and the properties required to prevent corrosion under diverse circumstances. Proper formulation for resistance to moisture transmission and the three modes of the latter (direct transmission, osmosis, and electroosmosis) are discussed. Also lists methods of surface preparation in order of effectiveness, describes methods of application and reviews uses.—BLR.

**Outdoor Aluminum Paint.** *Modern Metals*, 4, No. 8, 33 (1948) Sept.

A new type of ready-mixed paint that will resist heat up to 1,000° F. (538° C.) and will not blister and peel off when hard rains hit the extremely hot surfaces, is announced by Aluminum Industries, Inc., Cincinnati, Ohio. In laboratory tests this aluminum paint, Permite No. 1901, was subjected to heat

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from a Bunsen burner as well as cold water sprays, and after six months the finish showed no signs of cracking, blistering or peeling and still retained its brilliancy. Several test applications of Permite No. 1901 were made over a year ago by industrial firms on outdoor heated surfaces where there had been repeated paint failures, and no deterioration whatever is apparent to date.—ALL.

**Electroplate on Magnesium.** *Metal Prog.*, 54, No. 2, 228, 230 (1948).

Summary of a paper by William Loose presented before the March 1948 meeting of the Magnesium Association. It deals with the surface cleaning of magnesium and the deposition of a zinc film and a copper layer before the electrodepositon of the required metal.—MA.

**Removal of Paint and Lacquer Films (on Metals).** *Metallüberfläche*, 1, No. 8, 199 (1947).

Mechanical, chemical, and electrolytic methods are reviewed. Small parts can be satisfactorily treated, without attack of the basic metal, by alternate anodic and cathodic treatment (10 sec. reversal time) in an electrolyte containing sodium hydroxide 85, sodium phosphate 40, and waterglass 10 g./l., using a c.d. of 5 amp./dm.<sup>2</sup> at 2-5 V.—MA.

**Porosity in Electrodeposits.** *Metal Ind.* (London), 73, No. 18, 349 (1948) Oct. 29.

A method for studying porosity in electrodeposits has been developed by the Research Committee of the American Electroplaters' Society. The electrodeposited foil is stripped from the base metal and its permeability to gas is measured. Experimentally, a characteristic constant for each metal is obtained. This is the time required to reduce a given pressure difference across the foil to half its original value. It is believed that this method gives the first reproducible quantitative measurements on porosity that have been obtained.—ALL.

**Anodic Coatings on Aluminum and Their Protective Value.** D. M. McLACHLIN AND H. P. GODARD. *Can. Chem. Process Ind.*, 33, No. 2, 124-128 (1948) Feb.

Describes mechanism of growth of anodic film and methods of anodizing using various electrolytes. Properties of anodic films are discussed under 11 headings, including resistance to hot water and chemical environments. 24 references.—BNF.

**Electrodeposited Zinc Coatings.** RICK MANSELL. *Metal Fin.*, 46, 63-69 (1948) Dec.

Following an introduction, the following topics are dealt with: zinc plating baths; surface preparation prior to zinc plating; cyanide zinc plating; bright zinc plating; typical procedure for bright zinc plating of aircraft parts; passivation of zinc coatings; acid zinc plating; and fluoborate zinc baths.—BNF.

**Package Structure and Water-Vapour Protection.** C. G. LAYERS. *Modern Packaging*, 22, No. 3, 157-159 (1948) Nov.

Flexible water-vapor barriers were tested to determine the effect of style and type of closure of containers on their water-vapor resistance. For the handling experiments, both a light (450-MSY<sup>2</sup> cellophane) and a heavy (Reynolds Metals A-10, a lamination of kraft to metal foil to cellophane) barrier material were used. It was shown that, after handling, flexible water-vapor bar-

rier used as a carton liner gave better protection than if used as an overwrap. Different styles of containers, with various types of closures, were tested for water-vapor resistance, using four different materials, as follows: Reynolds Metals A-51 (kraft paper laminated to metal foil coated with a thermoplastic), 300-MSAT cellophane coated 40 lb. per ream with a flexible wax composition, 55 lb., laminated bleached glassine coated on one side with a heat-sealing composition, and 300-MSAT cellophane. There was little difference in the water-vapor resistance of the various styles of liner bags when made from Reynolds A-51, or from the wax-coated cellophane, because these materials are readily sealed and are not sensitive to creasing. Materials sensitive to creasing, such as glassine or the unwaxed cellophane are best utilized for the simpler types of bags. With Reynolds A-51, heat-sealing construction was only slightly superior to glue-sealing construction.—ALL.

**Action of Antifouling Paints; Effect of Nontoxic Pigments on the Performance of Antifouling Paints.** BOSTWICK H. KETCHUM AND JOHN C. AYERS. *Ind. Eng. Chem.*, 40, 2124-2127 (1948) Nov.

Inclusion of nontoxic pigments in paints with insoluble matrices does not affect leaching rates or fouling resistance provided the proportion, by volume, of the toxic pigment in the dry paint film is greater than the minimum critical value. In paints with a soluble matrix, introduction of a nontoxic pigment results in higher leaching rates at equal toxic-volume fractions. Above a minimum critical toxic-volume fraction, however, fouling resistance is satisfactory regardless of the presence or absence of the nontoxic pigment.—BLR.

**The Use of Plastics as Lining for Chemical Plant Equipment.** C. KELETI. *Can. Chem. Process Ind.*, 32, No. 11, 1007-1008 (1948) Nov.

Plastics proved themselves in meeting demand of industry in lining chemical plant equipment. Plating solutions of nickel and cadmium were kept in vats lined with vinyl resins, as long as temperature range was maintained within limits of 50-70° C. Polystyrene is used for pipe-lining, handling corrosive solutions.—INCO.

**Coating for Metal Removed with Ease.** *Iron and Steel Engr.*, 25, No. 2, 108 (1948) Feb.

Peel-Cote, a protective coating for metal parts, which can be quickly peeled off, is a quick drying vinyl-based, chemically inert coating designed to protect from scratches, chips and corrosion. Applied by spray or dip methods, it is available in clear transparent or solid hiding black. Mfd. by Watson-Standard Co.—INCO.

**High-Temperature Ceramic Coatings for Steel.** Summarized from paper by W. N. HARRISON. *Ind. Heating*, 15, 1804 (1948) Oct.

Outlines work at the National Bureau of Standards as a result of which a new type of ceramic coating for high-temperature protection of mild steel was developed. Properties and applications are described at length. The composition of the NBS Type A-19 coating is: 50 parts infusible frit, 25 parts clacined alumina, 10 parts enamels clay, and other minor ingredients.—BLR.

**Cleaning, Rustproofing and Painting Parts for Outdoor Metal Furniture.** ANON. *Industrial Finishing*, 24, No. 7, 44-6 (1948).

The conveyor system, described and illustrated, includes cleaning with hot alkaline spray, spraying with rustproofing solution, a hot chromic acid rinse, hot drying, cooling, dip coating, baking the enamel finish and packing.—RPI.

**Field Application of Protective Coatings Facilitates Conversion of Old Paper Mill.** R. P. HILL. *Corrosion*, 4, No. 8 (1948) Topic of the Month, 1-2.

Corrosion problems in putting into use an old paper mill were successfully tackled by application of baked phenolic resins, solvent-suspended vinyls, and solvent-suspended or sheet neoprene, applied according to the requirements. Iron intake into process which would have affected the bleach of products was largely eliminated.—RPI.

**Statistical Analysis of Test Data on Accelerated Weathering of Panels.** R. HILL, G. COOK AND W. E. MOYER. A.S.T.M. Symposium on Paint and Paint Materials, No. 75, 107-115 (1947).

The results of experiments to compare 5 weatherometers from the point of view of color change are given. Numerical measurements of change in dominant wavelength, relative brightness and purity, were analyzed statistically and, after suitable changes in the operation of the two machines had been made, no significant difference was recorded between the machines or 4 colors tested when dominant wavelengths was considered. The other properties did show slight differences.—RPI.

**Corrosion Protective Paint of Today** (In German). HUBERT HESSE. *Metallüberfläche*, 1, 261 (1947) Nov.-Dec.

Gives results of experiments made to find methods of economizing on linseed oil (in short supply in Germany). Thorough mixing with pigments and use of the more viscous linseed oils proved helpful. Oxidation and polymerization were also successfully used to convert crude oil into drying oils, suitable for use in paints.—BLR.

**Protection of Steel by Means of Non-Water-Excluding Coatings.** F. J. HARMANN. *Verfkrönick*, 21, No. 7, 156-6 (1948).

A general review is given with some observations from the work of C.I.M.C. Corrosie-Commissie IV. Subjects discussed include: the best media for use in red lead paints; iron oxide and iron oxide/zinc oxide chrome paints; metal pigment paints; comparison of spray and brush application of anti-corrosive paints.—RPI.

**Fungi and Tropical Deterioration.** W. GRUPP. *Org. Fin.*, 9, No. 2, 4143 (1948) Feb.

The problem of finding efficient fungicides, and their relative corrosiveness on metals are briefly discussed. Various preventives are named and reference is made to research work carried on during the war and continued by various agencies now. "Prevention or Deterioration Abstracts" are available through the National Research Council, Washington, D. C.—INCO.

**Exhaust Valve Coatings Resistant to Lead-Compound Attack.** R. GRAHAM AND P. G. PIGNEGUY. *Shell Avia. News*, No. 11



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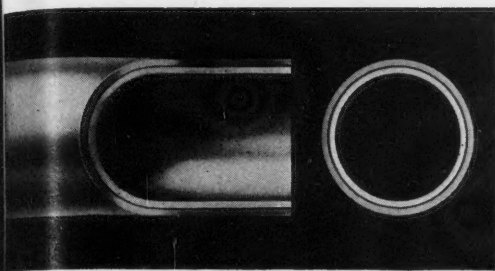
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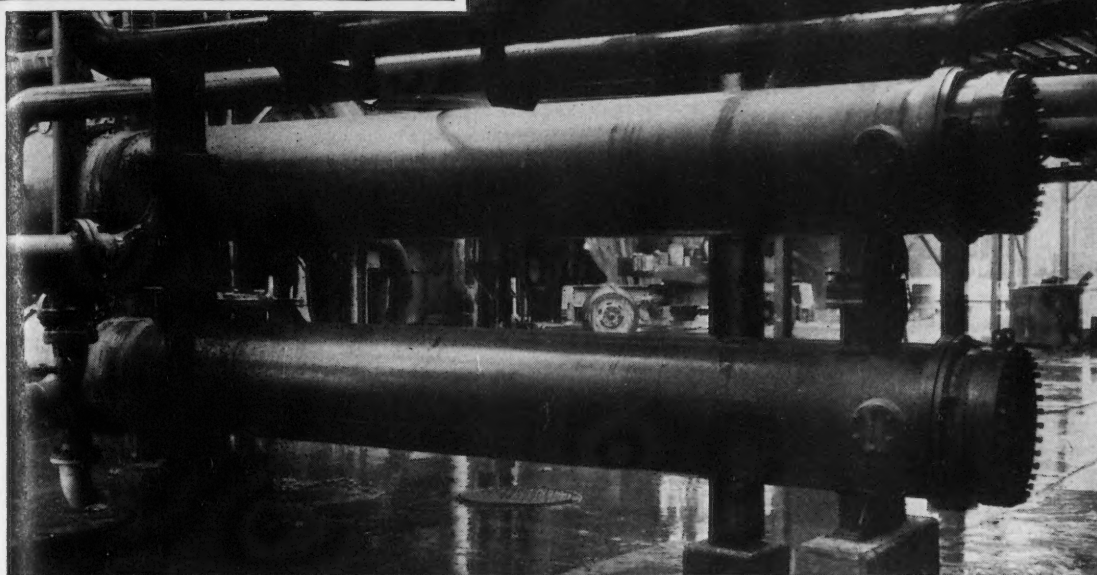
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14-21 (1948) May; *Aeronaut. Eng. Rev.*, 7, No. 10, 58, (1948) Oct.

Development of a Ni-Co-Al ternary alloy coating because of failure of Ni-Al alloy coating applied to exhaust-valve heads. Tests showed that the ternary alloy resisted corrosion from leaded fuels by the formation of an oxide coating.—INCO.

**Fungicide for Cork.** C. D. COOK AND R. HARRINGTON, General Electric Co. *Prod. Eng.*, 19, No. 6, 107 (1948) June.

To determine corrosion hazards, samples of beta naphthol and salicylanilide treated cork, salicylanilide crystals, and plain cork were placed in contact with strips of brass, aluminum, silver-coated brass, nickel-plated brass, galvanized steel and copper, and exposed to same atmosphere as used in testing for fungi growth. Except for slight tarnishing of copper in contact with salicylanilide treated cork, no corrosion occurred, thus confirming other reports that showed that salicylanilide is non-corrosive or even corrosion inhibiting.—INCO.

**Tin Coatings and the Resistance of Tin to Corrosion.** BRUCE W. GONSER. *Metals Handbook* (Amer. Soc. Metals), 1067-1069 (1948).

G. describes the hot tinning and electro-tinning of non-ferrous metals, chiefly copper and its alloys, to increase their corrosion-resistance. The resistance of tin itself to corrosion in the atmosphere and in aqueous solution is briefly summarized. 10 references are given.—MA.

**Mildew of Painted Surfaces.** M. GOLL AND G. COFFEY. *Paint, Oil Chem. Rev.*, 111, No. 16, 14, 16-7 (1948).

From an extensive examination of mildewed paintwork it is concluded that organisms of the genus *Pullularia* are the main cause of mildew on exterior and interior painted surfaces. This fungus causes a grey-black discoloration and imbeds itself deeply in the paint film destroying its continuity. In all, 30 organisms of 11 genera were isolated from mildewed paint surfaces. *Aspergillus* and *Penicillium* appeared to be chance contaminants. *Alternaria*, *Trichothecium* and *Spicaria* were common in food plants, *Cephalosporium* and *Cylindrocephalum* in breweries and distilleries, and *Stemphylium* in textile mills. On exterior paints, *Cylindrocephalum*, *Phoma* and *Alternaria* were frequently encountered. Photomicrographs of several of these fungi are shown. To demonstrate the presence of mould growth on paint surfaces when it is masked by dirt collection, the area should be flooded with 10% aq. potassium hydroxide, dirt, pig., etc. are adequately removed in 10-20 minutes, revealing the fungus elements embedded in the paint film.—RPI.

**New Coating Compound.** *Eng. News-Record*, 140, No. 26, 108 (1948) June 24.

Eternacote, for coating concrete pipe, is of transparent liquid organic chemical compound with a pure rubber base. It is a low-cost, permanent, glass-like coating for protection of concrete pipe against sulfuric and other sewage acids. Mfd. by George W. Hoffman Corp.—INCO.

**Fungicides in Protective Coatings.** OTTO EISENSCHIML AND VICTOR KALBERG. *Paint, Oil Chem. Rev.*, 111, 17-18 (1948) Nov. 25.

Presents experimental results on use of copper-8-hydroxyquinolinolate in protective

coatings—lacquers, paints, and varnishes. Results of Petri-dish tests are illustrated. They were very satisfactory, even when subjected to prolonged exposure at temperatures of 270° F. A solubilized material containing a carrier consisting of 50% naphthenic acid and 50% xylene was developed which is suitable for addition to commercial coating formulas.—BLR.

**Outside Exposures of Wood Primers. Influence of Extenders on Durability.** R. DOOPER AND F. J. HERMANN. *CIMO Circ.*, No. 52, 5 p. (1948).

The influence of extender pigments on the durability of primers for outdoor timber work has been investigated. Zinc oxide was used as the main primer pigment and extended with whiting, blanc fixe or barytes in varying proportions. Three primer media were used, viz., raw linseed oil and 2 oil-modified alkyd resins. In some cases the pigment medium ratio was varied. All primers were applied to flatgrain spruce panels and tested in a standard painting system with finishing paints based on zinc oxide or lead titanate with linseed stand oil. Two-year exposures at 45° facing South were carried out. In a single system with the same primer medium and the same finishing paint the amount or type of extender pigment or the pigment/medium ratio in the primer had no influence on durability. Better results were given by linseed oil than by alkyd primers and by lead titanate than by zinc oxide finishing coats.—RPI.

**Painting of Non-Ferrous Metals.** G. T. DINKLEY. *Mech. World*, 4, 653-7 (1948); *Prod. Fin.*, 1, No. 4, 67 (1948).

A review. Specially formulated paints are recommended with notes on surface preparation and methods of application.—RPI.

**Protective Properties of Anodic Films on Aluminum.** *Die-Castings*, 6, No. 8, 46-47 (1948).

The properties of anodic coatings and some factors affecting them, are discussed.—MA.

**Protection of Metal Surfaces by Tin Diffusion (G).** Deutsches Kupfer Institut. *Metalloberfläche*, 1, No. 8, 185-187 (1947) Aug.

The process described is applicable to copper, brass and special brasses as well as iron and steel. The work is immersed in fused stannous chloride (350-450° C.), tin being deposited by chemical replacement. One advantage over dip-tinning is the small dimensional change involved. Process was tested by German armed forces, e.g. for marine service.—BNF.

**Zinc Film Permits Plating On Magnesium.** H. K. DE LONG. *Machinist (Eur. Ed.)*, 92, No. 17, 518-520 (1948).

Magnesium can be nickel-plated by the Dow process, in which a thin film of zinc is first applied to the magnesium. The work is polished, and cathodically cleaned at 180°-212° F. (80°-100° C.) at 6 V., with c.d. of 40 amp./ft.<sup>2</sup>, in a bath containing trisodium phosphate 30, sodium carbonate 30, and sodium hydrate 15 g./l. After rinsing, the work may require a bright chromic acid dip, and in any case is given a 2-5 min. dip in a 15% hydrofluoric acid solution. The work is then pickled for 30-90 sec. in a 20% aluminum chloride solution and covered with a zinc film by dipping in

a solution of tetrasodium pyrophosphate 120, zinc sulphate 40, and potassium fluoride 10 g./l., with enough potassium carbonate to bring the pH to 10.2-10.4 at 170°-180° F. (70°-80° C.), the time of dipping being fairly critical. The work is then ready for conventional nickel plating.—MA.

**Double-Coating Metal.** ANON. *Decorator*, 47, No. 554, 75 (1948).

When a specification calls for only one coat of cellulose enamel on vertical surfaces, a heavy coat must be applied. One method of avoiding sagging is to spray first with a very thin coat (about 80% thinners) which will set up in a few minutes and can be followed almost immediately by a full coat.—RPI.

**A Protective Filming Process for Tinplate (Protecta-Tin).** H. R. CLAUSER. *Mat. & Meth.*, 26, No. 2, 97-100 (1947); *CF Met. Abstracts*, 15, 240 (1948).

In the Protecta-Tin process, tinplate is dipped for 20 sec. at 140° F. (60° C.) (or for shorter times at higher temp.) in a solution containing crystalline trisodium phosphate 24, sodium dichromate 9-6, sodium hydroxide 26-4, and a wetting agent 3-5 g./l. The plate is then washed. The film formed gives protection from sulphur staining, retards rusting, and provides a good base for paint on very thin electro-tinned plate.—MA.

**Chromated Protein Films Inhibit Corrosion.** National Bureau of Standards. *Bur. Standards Tech. News Bull.*, 32, No. 6, 67-8 (1948).

A metallic surface coated first with casein, albumin, or gelatin and then impregnated with chromate has superior temporary storage corrosion resistance to oil film treatments. The advantages and limitations are discussed.—RPI.

**Copper 8-Quinolinolate (Copper 8-Hydroxyquinoline) as Industrial Preservative.** P. G. BENIGNUS. *Ind. Eng. Chem.*, 40, No. 8, 1426-9 (1948).

Its main use is for the preserving of fabrics but it may also be used as a fungistat in protective coatings.—RPI.

**Studies on Anti-Fouling Compositions. Part V. The Behaviour of Mercuric Oxide in Some Anti-Fouling Compositions with Special Reference to the Leaching-Rate Test.** H. BARNES. *J. Iron and Steel Inst.*, 160, 177-184 (1948) Oct.

Differences in properties, particularly with respect to leaching rate of cuprous oxide and mercuric oxide compositions were studied. It is suggested that one of the most important factors is the formation of mercury soaps and that the standard leaching-rate technique cannot be applied to mercuric oxide compositions. Experimental results support this hypothesis. The effect of mercuric oxide on the properties of the medium is briefly considered. Soap formation appears to give a more resistant varnish medium. As a result, the leaching rate of cuprous oxide compositions containing large quantities of rosin can be reduced by the addition of moderate quantities of mercuric oxide. Performance data indicates that organic mercury is less effective as a poison than the inorganic form.—BLR.

**Plastic Coating for Alclad Metal.** *Automotive Industries*, 99, No. 9, 52 (1948) Nov.

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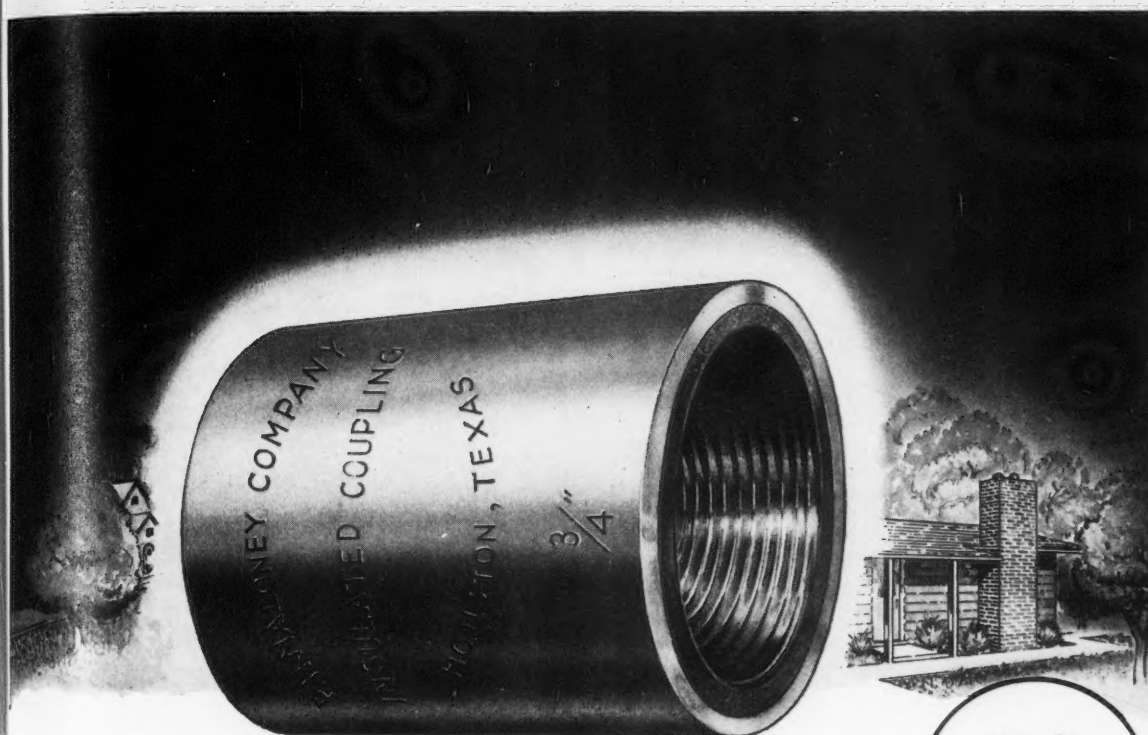
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**Methods of Evaluation of Marine Finishes.** A. L. ALEXANDER. *ASTM Symposium on Paint and Paint Materials*, No. 75, 46-59 (1947).

The final evaluation of coatings must depend on exposure tests and methods of carrying out such tests are described. Laboratory tests give indications as to value and, of these, leaching tests for anti-fouling paints are among the most promising.—RPI.

**Coatings For Insulation, Surface Hardening, Lubrication, Paint Bases and Protection.** *Electronics*, 21, No. 6A, M10-M13 (1948).

The methods of obtaining surface coatings of metals and plastics are described. Short descriptions of ways of preparing the base materials are given, as well as information on the special qualities of the coated materials.—MA.

**Principles of Protecting Metals with Organic Coatings.** E. J. Eickhoff and W. E. Shaw. *Corrosion*, 4, 463-475 (1948) Oct.

Reviews theoretical aspects and gives recommendations for surface preparation and for selection and application of coatings. 23 ref.—BLR.

**The Painting of Non-Ferrous Metals.** G. T. Dunkley. *Mech. World*, 123, No. 3203, 653-657 (1948).

A concise account of painting and other protective treatments for non-ferrous metals.—MA.

**Aluminum Coating of Steel.** Armand di Giulio. *Light Metal Age*, 7, Nos. 5/6, 8-9 (1948).

Aluminum coating offers a cheap method of protecting steel against corrosion and oxidation. The methods generally employed are "calorizing," hot dipping, and depositing aluminum from aluminum chloride vapor. Other possible methods are casting and brazing. The hot-dipping process is described in detail.—MA.

**Note on a Protective Grease for Threads Exposed Under Corrosive Conditions.** M. Cohen, A. C. Halferdahl, and I. E. Puddington. *Canadian J. of Res.*, 26, sec. F, 347-348 (1948) Aug.

Five greases or oils were evaluated in connection with tropicalization of motor vehicles, using a severe cycle of seawater immersion and moisture condensation. After 10 weeks, steel plate, bolt and nut assemblies were tested for ease of removal of bolts. The ones lubricated with an inhibited aluminum stearate grease (composition given) were much more easily removed than any of the others.—BLR.

**Hard-Facing Materials.** H. R. Clauser. *Mat. and Meth.*, 25, No. 6, 103-118 (1947). (A Materials and Methods manual.)

The characteristics of the alloys used for hard facing are reviewed, the fac-

tors governing their selection and use are discussed, and an account is given of the methods by which the materials may be applied. A comprehensive list of the trade names, compositions, and characteristics of American commercial hard-facing electrodes is appended.—MA.

**Painting Aluminum.** James Clark. *Prod. Fin.*, 1, No. 2, 37-41, 82 (1948).

Methods for the cleaning, chemical pre-treatment, and painting of aluminum surfaces are described and discussed.—MA.

**Should the Use of Red Lead for Ship Hull Protection be Discontinued?** M. Chardome. *Peint. Pig. Vernis*, 24, No. 2, 42-5 (1948).

A review of published work.—RCLPI.

**Fungicidal Plastics.** H. Kolin. U. S. Army, Signal Corps, Contract W-36-039-sc-32355, Repts. Nos. 2-4. *Prev. Det. Abs.*, 4, Plas. 28-30 (1948).

From literature and exptl. data available it appears that none of the commercially available fungistatic plastics is completely satisfactory. Ten fungicides were tested for cell acetate plastics and eight for GR-S rubber. In all cases but one the incorporation of a fungicide tended to lower the ultimate tensile strength of the plastic.—RCLPI.

**Impregnating Steel with Aluminum.** *Steel*, 123, No. 8, 110 (1948) Aug. 23.

The impregnation of steel with aluminum improves heat conductivity and serves as a protection against rust, acids, fumes and corrosive atmospheres. The method, designated Mollerizing after its inventor, was developed in Sweden a number of years ago and licenses for use of this process are now being issued in the United States and Canada. Standard electric salt bath furnaces are used. The base metal is degreased, descaled, thoroughly cleaned and lowered into the furnace containing principally barium chloride on which is floated a bath of pure aluminum. When the metal being treated has been raised to the heat of the salt, 1600-2000° F. (871-1093° C), it is removed through the aluminum. As a result of the impregnation aluminum enters the pores of the steel, thereby forming an iron-aluminum alloy which when quenched may have a hardness as high as 550 Brinell and an exterior layer is deposited which has all the corrosion-resistant properties of pure aluminum. Aluminum impregnated metals will take anodizing and coloring the same as aluminum and can be polished by the same methods. The impregnation of wire and other electrical equipment improves conductivity of the metal.—ALL.

## CHEMICAL

**Inter-crystalline Failure of Brasses and Aluminium Brasses in Air, Ammonia, and Certain Aqueous Solutions and Molten Metals.** M. E. WHITAKER. *Metallurgia*, 39, No. 229-230, 21-29, 66-70 (1948) Nov.-Dec.

Work done by the B.N.F.M.R.A. This paper is a summary of investigations carried out by E. Voce and A. R. Bailey from 1940-1946 and described in R.R.A.'s 560, 598, 669 and 728. The first section of the research covers the

behaviour of plain brasses and aluminum brasses (mainly extruded but in the same cases cast) in various cracking media (mercurous nitrate, solution, ammonia, sea water and molten solder; tin and lead). Second section deals with susceptibility of certain cast aluminum-brasses to intercrystalline failure under conditions of stress unaccompanied by corrosion. The paper is well illustrated with photomicrographs showing the various types of failure. This is the published version of R.R.A. 782, announced to members in April, 1948.—BNF.

**The Corrosion of Mild Steel by Ammonium Sulphate.** A. M. WARD. *Industrial Chemist and Chemical Manufacturer*, 24, 722-724 (1948) Nov.

Presents results of experiments on the above.—BLR.

**The Effect of Metals in Milk and Milk Products.** R. WAITE. *J. Soc. Dairy Technol.*, 1, 8-11 (1947); discussion 11-13; *Nickel Bull.*, 21, No. 2, 28 (1948).

A review of published information, with a bibliography of 38 references.—MA.

**Causes and Prevention of Drill Pipe and Tool Joint Troubles. Part 3, Drill Pipe.** H. G. TEXTER, R. S. GRANT, and S. C. MOORE. *World Oil*, 128, 100 (1948) Dec.

Deals with corrosion-fatigue failure of drill pipe. It has recently been shown that salt, of relatively low concentration, is the principal cause of corrosion fatigue. Illustrated by photographs showing service failures and test-specimen results. Begins discussion of hydrogen or hydrogen sulfide embrittlement. (To be continued).—BLR.

**Increasing Corrosion Resistance—Recent Tests with Stainless Steels.** H. SEYMOUR. *Chem. Age*, 59, 191-192 (1948) Aug. 7.

In a discussion of the properties, compositions, and methods of passivation of some stainless steels, it is shown that increased corrosion resistance is brought about by a passivation treatment which consists of exposing the steel to boiling 10% sulfuric acid for 3 minutes, washing thoroughly in water, and then exposing the steel to air. Passivation of stainless steels by exposure to warm dilute nitric acid is also recommended.

**Corrosion Caused by Motor Fuels (in German).** P. SCHLAFER AND A. BUKOWIECKI. *Schweiz. Arch. Angew. Wiss. u. Tech.*, 14, 257-274 (1948) Sept. (In German with French and English summaries.)

Discusses the available literature on the above, including the effect of their water content and their physicochemical characteristics. Presents results of experimental investigation on the basis of which motor fuels are classified into definite groups with respect to their corrosion behavior. Deals only with attack on ferrous metals. Photographs, diagrams, and tables. 38 ref.—BLR.

**Corrosion of Pressure Vessels Used for Storage or Transport of Gases.** P. SCHLAFER AND A. BUKOWIECKI. *Schweiz. Ver. Gas u. Wasserfach. Monats-Bulletin (Switzerland)*, 28, 105-113 (1948). *Chem. Absts.*, 42, No. 21, 8145 (1948) Nov. 10.

Steel containers for liquefied gases are generally made of 0.3 to 0.45% carbon steel; higher carbon content is undesirable.

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ble. Lighter construction is allowable with nickel or nickel-chromium-molybdenum alloy steels; their corrosion resistance is, however, often no better than that of steel. Various aluminum alloys are in use and proper for most noncorrosive gases. Very few of the compressed gases even including chlorine, nitrous oxide, sulfur trioxide, hydrogen chloride or hydrogen sulfide attack steel or aluminum if properly dried. It is most important to avoid the presence in the bottles of small amounts of water. Examples are given of severe corrosion in pressure vessels with oxygen or illuminating gas in the presence of small amounts of water. The attack of metal is particularly frequent if a separate aqueous phase is present locally on the walls; this holds for permanent gases like boron fluoride, illuminating gas, oxygen and compressed air as well as for liquefied gasses like chlorine, hydrogen chloride, phosgene, sulfur dioxide, hydrogen sulfide and carbon dioxide, also for chlorinated hydrocarbons. With illuminating gas the hazard of transcrystalline cracks can be avoided by using steel with less than 0.4% carbon. In aluminum vessels the same gases are dangerous. The test work has not been completed.—ALL.

**Corrosion in the Exhaust Pipes of Internal-Combustion Engines (Cast Iron and Copper).** GERHARD SCHIKORR. *Metallüberfläche*, 2, No. 4, 73-79 (1948).

A general description is given of the reactions which may occur between the products of combustion and the exhaust-pipe materials of internal-combustion engines, and an apparatus is described whereby this corrosion can be studied at various positions in the pipe, i.e. corresponding to different exhaust-gas temperatures. Results are given for pipes made of cast iron and copper acted upon by an exhaust gas of the composition, carbon dioxide 11.5, carbon monoxide 0.1, oxygen 2.6, water vapor 11.0, and nitrogen 74.8%. At 400° C., cast iron suffers rapid initial attack, but after one day the rate falls to approximately 0.06 mm./year; at 180° C. the rate of attack is so small as to be of no consequence, but at 70° C. it is again considerable and probably attains a rate of 1.4 mm./year. Like cast iron, copper is rapidly attacked at 400° C., but, unlike cast iron, the scale formed gives no protective action; at 180° C. the rate of attack is approximately 0.03 mm./year, and at 70° C. approximately 0.08 mm./year.—MA.

**Transportation and Storage of Strong Nitric Acid.** G. A. SANDS. *Ind. Eng. Chem.*, 40, No. 10, 1937-1945 (1948) Oct.

Investigation of materials for the transportation and storage of strong nitric acid was carried out by a special sub-committee of the Manufacturing Chemists' Association. The first part included corrosion tests on two grades of aluminum drums, supplied by the Aluminum Company of America, and six grades of stainless steel supplied by Stevens Metal Products Company, Niles, Ohio, exposed to the liquid and vapor phases of 93, 95, 97, and 99% nitric acid for three 30-day periods at temperatures of 130° F. (54° C.). The specimens tested represented the various conditions of fabrication and heat treatment encountered in the manufacture of drums. In addition, all specimens were subjected to five 48-hour periods in the standard 65% boiling nitric acid test to determine: effect of cold working, effect

of heat from welding, effect of heat treatment, and the quality of stainless steel welds and parent metal. The second part of the investigation included corrosion tests on Type 304, 18-8 stainless steel, and two grades of aluminum (99.6 and 3S) exposed to liquid and vapor phases of 93, 95, 97 and 99% nitric acid for three 30-day periods at temperatures of 90 and 110° F. (32.2 and 43° C.). These temperatures more nearly approached actual transportation and storage conditions and added to the original data serve the purpose of determining the effect of temperature in accelerating corrosion. Weather-exposure storage tests were made on Type 347 stainless steel drums but aluminum drums were not available for comparable tests.

Results of the tests showed that all grades of stainless steel and aluminum tested could be used for drums or storage containers for 93 and 95% nitric acid. Stainless steel must be properly heat treated or contain the stabilizing agent columbium. Heat treatment is not essential for aluminum. Both aluminum and stainless steel appear to have equal corrosion resistance in these concentrations. Type 18-8, Grade 304 properly heat treated, or columbium-bearing Type 347 non-heat-treated, and aluminum Grades 99.6 and 3S may be used as construction materials handling 97 and 99% nitric acid. In the case of stainless steel, heat treatment subsequent to fabrication is mandatory unless columbium is used. The corrosion resistance of aluminum in these concentrations is much superior to that of Types 304 and 347 stainless steel. Drums made from these grades of stainless steel are safe for transportation and storage of 97 and 99% nitric acid, but their utility will depend on the severity of storage conditions and the quality of acid required. In view of the reports from various sources regarding the successful use of Types 304 and 347 stainless steel for drums handling 97 to 101% nitric acid, it would appear that the conditions of the tests carried out in this investigation were more severe than actual practice. This is a summary of results of a cooperative testing program sponsored by the Metal Packages Committee of the Manufacturing Chemists Association.—ALL.

**Operating Experiences with Cottrell Precipitators on Sulphate Recovery Furnace Gases.** L. M. ROBERTS, C. E. BEAVER, AND W. H. BLESSING, Research Corp. Paper before TAPPI, Alkaline Pulp Comm., Asheville, Oct. 11, 1947; *Paper Trade J.*, 127, No. 18, 45-49 (1948) Oct. 28.

Operating data and plant experience with Cottrell precipitators for recovery of sodium compounds from recovery furnace gases. Whole construction of precipitator is such as to guard against corrosion. Mention is made of corrosion resulting from sulfur compounds as well as from chlorine combinations.—INCO.

**Chemical Cleaning of Boilers, Pipe-Lines, Hot-Water Tanks, etc., Use of Aluminium as Inhibitor.** ERICH RABALD. *Metallüberfläche*, 1, No. 11-12, 262-263 (1947).

Discusses the economics of scale removal from iron vessels by the use of hydrochloric acid in various concentrations at 20° C. The addition of small quantities of metallic aluminum is recommended, as this acts as an efficient inhibitor of solution of the container with-

out affecting the efficiency of the scale removal.—MA.

**Beständigkeit von Aluminium gegen Bohrolemlösungen (Stability of Aluminium Exposed to Cutting Oil Emulsions).** Vereinigte Aluminium-Werke A.G., Lautawerk, Ger. (Geller). Office of Sci. & Tech. Development, PB-70016, Frames 6571-6574 (1947) Aug.

Oil emulsions of two slightly acidic soluble oils, produced by Rhenania-Ossag Co., in dilutions of 1:15-1:35, inhibit the corrosion of aluminum in tapwater and in 0.5% acetic acid but not in a 0.5% soda solution. When the latter is used to soften hard water for preparing the emulsions it is advisable to add 1-2 ml. of commercial waterglass of about 40° Bé; this represses the attack of the soda without influencing the emulsifying action of the soluble oils.

One test series was carried out on an aluminum-copper alloy known to have a comparatively low corrosion resistance. Weight losses on sheets 1-mm. thick and 3330 sq. mm. in surface area were recorded after the sheets had been immersed constantly for 8 days in 500 ml corrosive liquid at room temperature and then for 12 days with alternate 10-hr. dipping and 14-hr. drying periods. Acetic acid changed the oil compositions and impaired their ability to emulsify.

Another test series was carried out on hard, 99.5% pure aluminum. Some samples were immersed for 48 hours and others were exposed in the alternate dipping apparatus for 7 days. The corrosive action of 1 g soda per liter was inhibited by 1 ml. per liter of waterglass in both tests. As much as 9 ml. of waterglass per liter did not impair the emulsifying action of the oils.—DPA.

**Modern Wire-Pickling Practice and Plant Design. I. II.—Copper-Rod Pickling. III.—Construction of Pickling Tanks: Acid Storage. IV.—Acid-Recovery Systems.** EDWARD MULCAHY. *Wire Ind.*, 14, No. 161, 269-271; No. 162, 321-322, 330; No. 163, 377-380; No. 164, 441-442 (1947).

I. Equipment for pickling ferrous rods and wires is considered. II. Recovery of copper by electrolysis or by crystallization as copper sulphate is described. Pickling solutions should be operated at 60-70°C., and agitation is essential. III. Constructional details are described, and some typical designs illustrated. IV. Recovery of iron salts from spent pickle liquors is discussed.—MA.

**Corrosion by Molten Materials.** F. R. MORRAL, American Cyanamid Co. *Wire & Wire Products*, 23, No. 6, 484-489 (1948) June; No. 7, 571-579 (1948) July.

Table of molten elements, mostly metals, is arranged so that molten material at given temperature attacks a construction material to give a corrosion rate. Table on corrosion in molten salts is arranged in the same manner. Table on corrosion of materials in salt mixtures is arranged with metal in a molten salt mixture at a given temperature to give a corrosion rate.—INCO.

**Crankcase Ventilation.** H. L. MOIR AND H. L. HEMMINGWAY, Pure Oil Co. Paper before SAE, Nat. Fuels and Lubricants Mtg., Tulsa, No. 7, 1946; *S.A.E. Trans.*, 1, No. 3, 389-407 (1947) July.

Crankcase ventilation is essential to correct a number of service conditions.



namely to control dilution; to reduce moisture condensation in engine; to remove varnish and sludge-forming components in blowby gases from crankcase atmosphere; to remove corrosive components from crankcase atmosphere; to reduce or eliminate engine fumes in vehicle body; and remove solid particles of soot or lead from crankcase atmosphere. Standard crankcase ventilating systems and homemade improvements on them are described. Illustrations are included.—INCO.

**Attack on Four Heat Resisting Alloys by Various Compounds After 17 Hr. Heating in Air at 1500° F. *Mat. & Meth.*, 28, 105, 107 (1948) Dec.**

Table shows qualitative effect of 60 inorganic compounds on S-816, S-890, Hastelloy B and Haynes Stellite No. 21. Other tables give compositions of the alloys and attack of 16 of the compounds in air, carbon dioxide and helium under the same conditions otherwise.—BLR.

**Corrosion Proof Motor. *Mat. & Meth.*, 27, No. 5, 73 (1948) May.**

Monel, cast bronze and brass are used in a new electric motor which is designed to be used under corrosive conditions. Monel, 3/32-in. thick, is used for the outside shell of the motor and for the fan cover. Cast bronze is used for the motor fan, replacing cast aluminum. Bronze is used for shaft collars, and brass for grease pipes. Motor is for service where such hazardous atmospheres as those caused by gasoline, oil, naphtha, alcohols, acetone, lacquer solvent vapors and natural gas might be present. Manufactured by Reliance Elec. & Eng. Co.—INCO.

**Concentration of Isotopes of Mercury in Countercurrent Molecular Stills. S. F. MADORSKY, P. BRADT & S. STRAUS. *J. Research Natl. Bur. Standards*, 41, No. 3, 205-210 (1948) Sept. (R.P. 1918).**

The metal parts exposed to mercury were made of stainless steel. The column rests on a Nichrome electric heater. Six references.—INCO.

**Corrosion-Resistant Gate Valve. *Mach. Design*, 20, No. 10, 144 (1948) Oct.**

Stainless steel gate valve for chemical, processing and food industries is so made that all parts contacting process fluid are of corrosion-resisting alloy Type 316. Packing and gaskets are corrosion resisting and yoke bushings are renewable. Manufactured by Ohio Injector Co.—INCO.

**Aluminium Containers in the Production of Resin. J. A. LEE. *Chem. Eng.*, 55, No. 11, 129-132 (1948) Nov.**

Aluminum containers and equipment are used extensively by the Hercules Powder Co. in the manufacture of resins and other synthetic chemicals. At its Mansfield, Massachusetts, plant the company produced the Pentalyn series of resins based on wood rosin and pentaerythritol. The molten rosin is pumped from tank cars through a jacketed aluminum line to storage tanks of aluminum outside the buildings. Aluminum coils in the tanks assist in holding the rosin in liquid state. In the manufacture of the Lewisol series of resins, maleic anhydride is received in galvanized drums, pumped through a jacketed stainless steel line to an aluminum weigh tank. The Petrex resins, based on resinous terpene polybasic acid and an alcohol are made in aluminum kettles

heated by circulating oil. Aluminum is used in this case to prevent discoloration.—ALL.

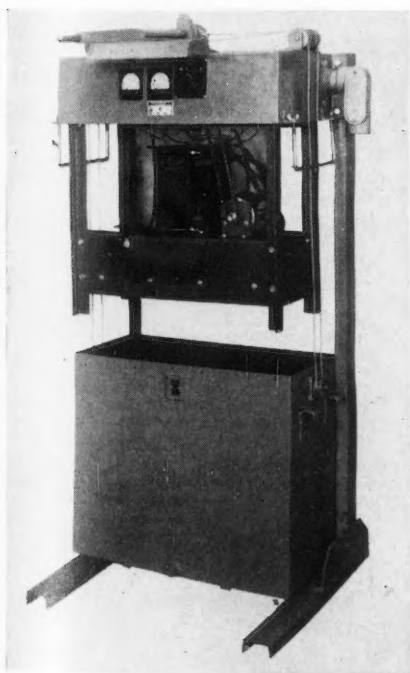
**Acid-Resisting Steel in Textile Industry. *Kunstseide*, 23, 259-261 (1941); *Brit. Abst.*, B. 1, 490 (1948) Sept.**

In contrast to normal 18:8:2 Cr-Ni-Mo steel, 19:9:2 steel containing silicon has no tendency to grain boundary corrosion after welding and is resistant to pitting in halogen-containing solutions; it remains unattacked after treatment with aqueous sodium hypochlorite containing 0.25 active Cl at 65° for 14 days. Tensile properties of steels are similar.—INCO.

**Light Aircraft Service Experience with All-Purpose Fuel. R. V. KERLEY, Ethyl Corp. Paper before SAE, Summer Mtg., French Lick, June 4, 1946; *SAE Trans.*, 1, No. 2, 253-263 (1947) April; Discussion 263-265.**

Data shows that light aircraft engines can be modified to operate on fuels having a lead concentration equal to that of grade 80 all-purpose fuel. Stellite-valve-seat inserts are used with ½ degree interference angle between valve and valve seat in engine used in L-4. Test using bronze valve guide with sodium-cooled silchrome 142 valves resulted in pitted valve faces and stem corrosion. Chromium-plating of valve stem in lieu of nitriding did not prove to be a solution since the plating scaled. Use of counterbored cast-iron or Ni Resist valve guides appeared to stop etching, but resulted in valve sticking. Illustrations are included.—INCO.

**Corrosion of Metals in Red Fuming Nitric Acid and in Mixed Acid. NATHAN**



• "NEMCO" Class 930 Selenium Rectifier, Oil-Immersed Type. Portable, tank-lowering windlass is shown on top of unit. Oil Tank is in lowered position for inspection. Cover has been raised over instruments and tap-changing switch.

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KAPLAN AND RODNEY J. ANDRUS. *Ind. Eng. Chem.*, **40**, 1946-1947 (1948) Oct.

A number of metals and alloys were tested to determine the above. Several stainless steels and Duriron exhibited good resistance to corrosion by concentrated nitric acid; aluminum alloys were more extensively attacked; Haynes-Stellite alloys and chromium were only slightly corroded; and tin, gold, and tantalum exhibited very good resistance, even at elevated temperatures. Corrosion rates in mixed acid were lower than in the other nitric acids for most of the metals tested.

**The Resistance of Lead and Lead Alloys to Corrosion.** G. O. HIERS. *Metals Handbook* (Amer. Soc. Metals), 951-954 (1948).

The behaviour of lead when used in the building industry (roofs and pipes), for cable sheathing, for storage batteries, for pickling and plating vats, and in the chemical industry is described, and the performance of lead in contact with many chemicals is listed.—MA.

**Corrosion Problems in the Manufacture of Soda Ash by the Ammonia Soda Process.** G. HEINEMANN. *Corrosion*, **4**, No. 11, 516-528 (1948) Nov.

The problem of corrosion in the manufacture of soda ash by the ammonia soda process has been a matter of serious concern for some time. In the equipment and piping for the manufacture of soda ash, cast iron is used almost universally with one notable exception. The high resistance of aluminum to ammonia and carbon dioxide in the absence of high chloride concentrations makes its use attractive for the cooling of the hot gases from the ammonia stills. These gases contain ammonia, carbon dioxide and traces of hydrogen sulfide. The coolers, which utilize fresh water as the cooling medium, are constructed of cast iron with a cast iron tube sheet into which aluminum tubes are inserted. These tubes give many years of service. Since aluminum is now materially cheaper than before the war, its use is economically justifiable in many cases where it might not have been true previously. Various types of organic tank coatings have been tried for the protection of the tank cars and storage tanks but completely without success, presumably because of the destructive effect of the impurities in the crude ammonia upon the coatings. Gunitite linings have been used successfully in the protection of steel storage tanks but are impractical for tank cars because of the added weight involved. There are indications that aluminum can be used very successfully in this application, although in the case of tank cars, the cost is felt to be prohibitive.—ALL.

**Corrosion of Copper in Hydrochloric Acid.** PAUL I. GEGNER. *Corrosion*, **4**, 619-620 (1948) Dec.

Describes experience in which copper cooling tubes were corroded by flushing periodically for scale removal with 16-20% hydrochloric acid plus an inhibitor. Available information indicates that intermittent exposure to this acid up to 24% concentration should not cause excessive attack. Experiments indicated that the corrosion was caused by the presence of ferric ions in the acid, resulting from the solution of rust scale from the tube sheet and header.—BLR.

**Corrosion by Sulphates.** W. Z. FRIEND. *Chem. Eng.*, **55**, 145-147 (1948) Nov.

Presents plant data from the files of International Nickel Company for number of inorganic sulfates.—BLR.

**Application of Aluminum in the Food-Oil Industry** (In Italian). R. FREZZOTTI. *Alluminio*, **17**, 342-347 (1948) July-Aug.

Two-year immersion in olive oil indicates that welded aluminum (99.0-99.5%) containers may be used for storage and transportation of the oil. Data are tabulated.—BLR.

**Petro-Chemical Operation.** A. L. FOSTER. *Oil Gas J.*, **47**, No. 12, 64-6 (1948) July 22.

In the commercial synthesis of basic organic chemicals by the direct oxidation of aliphatic hydrocarbons, corrosion of the equipment was combated by the use of stainless steels, chrome-nickel, chromium-nickel—molybdenum alloys and Monel.—INCO.

**The Occurrence of Metallic Contaminants in Foods.** G. E. FORSTNER. *Chem. & Ind.*, No. 32, 499-501 (1948) Aug. 7.

Discusses arsenic, lead (contamination likely from many sources, including foil, pipes and solders) copper, zinc, tin, antimony, cadmium, selenium; and methods of control, including control of metal foil used in wrapping and of printing inks used for paper wrappers. 18 references.—BNF.

**A Jam and Pulp Plant for South Africa.** *Food*, **17**, 13-18 (1948) Jan.

Robert Kellie & Son, Ltd., have recently completed and shipped to So. Africa a jam installation with capacity of 20 tons/day with several nickel containing materials as components: jam-boiling pans of copper with jackets of Ni-tron, a nickel cast steel alloy, and pulping, straining and separating machine is of stainless steel as well as elevator charging autoclaves.—INCO.

**Corrosion. New Development of Wrought Corrosion-Resistant Alloy Should Find Extensive Use in the Chemical Industry.** MARS G. FONTANA, Ohio State University, Columbus, Corrosion Research Laboratory. *Ind. Eng. Chem.*, **40**, No. 2, 87A-88A (1948) Feb.

The physical-chemical properties, production, and applications of Carpenter Stainless 20 wrought steel are reviewed and discussed. This alloy is new in that it is produced in wrought form though the composition is practically identical with Durimet 20 cast alloy. Designed primarily for resistance to sulfuric acid, it is also resistant to a wide variety of extremely corrosive chemicals and plant liquors. In sulfuric, hot acetic, and crude phosphoric acids, it is markedly superior to 18-8 alloys. It fills a gap between these and the very expensive high alloys and precious metals from the standpoints of both corrosion resistance and economy.

Carpenter Stainless 20 usually consists of 29% nickel, 20% chromium, a minimum of 3% copper, a minimum of 2% molybdenum, a maximum of 0.07% carbon, 1% silicon, and 0.75% manganese. The nickel content provides the basic resistance properties, especially to sulfuric acid, and keeps all the copper in solid solution. Free copper would contaminate the process liquors and impair good working properties. The chromium, molybdenum, and copper con-

tents impart good antioxidant properties, inherent and passive resistance to pitting, and good resistance to sulfuric acid, respectively. The low carbon content is essential for resistance to intergranular attack.

In strength and ductility this alloy is similar to 18-8 stainless steels; its machinability is good and it shows good hot forging and welding properties.

Carpenter Stainless 20 is austenitic and can not be hardened by thermal treatment, but only by cold working. A water quench from 2000-2100° F. imparts optimum corrosion resistance. Similar to 18-8S (Type 304), stainless steel is subject to carbide precipitation when heated or cooled slowly through the 900-1400° F. range. Accordingly, welded structures should be quenched after welding unless a thin sheet, a strip, or shot welding is involved.

The new wrought alloy can be used in numerous applications in practically every type of chemical industry. Its superiority to the cast alloy Durimet 20 is apparent in wrought valve stems which are far more corrosion-resistant than cast stems.—DPA.

**Corrosion Behaviour of Titanium.** M. G. FONTANA. *Ind. Eng. Chem.*, **40**, No. 10, 99A-100A (1948) Oct.

Author first gives details of mechanical and physical properties of titanium metal. Titanium showed poor corrosion resistance to 65% and 93% sulfuric acid. Corrosion in dilute hydrochloric acid increased rapidly with concentration. Behaviour in nitric and acetic acids was similar to 18-1S stainless steel. The 11% Cr alloy showed excellent resistance to the "standard" (65% boiling) nitric acid test. Oxidation tests in air at 1300° F. (870° C.) on three titanium-base alloys containing 4, 11 and 16% chromium showed formation of a double layer of scale.—BNF.

**Corrosion in Contact Sulphuric Acid Plant.** M. G. FONTANA. *Ind. Eng. Chem.*, **40**, No. 11, 88A (1948) Nov.; **40**, No. 12, 69A, 70A (1948) Dec.

Corrosion in contact plant equipment blowers, heat exchangers, absorbers, coolers, and valves and other equipment is discussed.—BNF.

**Corrosion of a Steel Ship in Sea Water.** K. N. BARNARD. *Can. J. Res.*, **26**, sec. F, 374-418 (1948) Sept.

The above was investigated by studying the electrical potentials in the sea close to the hull. The surveys were made in conjunction with the drydocking program during which the state of the hull was deliberately altered so that the corrosion patterns could be followed under a variety of hull conditions, and were supplemented by visual inspections. Typical results are described, tabulated, and illustrated. Some failures of the present anticorrosive technique are indicated and possible remedies suggested.—BLR.

**Aluminium in the Alcohol Industries.** J. P. BALASH AND E. D. VERINK, JR. *Chem. Eng.*, **55**, No. 10, 240, 242 (1948) Oct.

Chemical equipment and shipping containers made of aluminum are used extensively for industrial and beverage alcohols. At room temperature, commercial alcohols, such as methyl, ethyl, propyl, butyl, etc., are substantially without effect on aluminum and at

elevated temperatures aluminum is normally suitable provided a trace of moisture is present. Alcohols containing heavy metals or other contaminants generally can be handled successfully in aluminum by the addition of an inhibitor such as sodium chromate. Aluminum stills, heat exchangers, piping, tankage, and shipping containers have been used successfully for a long period with a variety of alcohols and products containing alcohol. An all-aluminum reflux condenser built of 2S alloy has been in continuous service for over 16 years condensing a 90% methyl alcohol, 10% formaldehyde mixture at temperatures around 50° C. (122° F.).

Aluminum alloys may be employed for alcohols produced both by the grain fermentation process and petroleum gas synthesis. Its non-toxic properties are an advantage in the production of citric and gluconic acids, penicillin and other anti-biotics. Other uses include high purity products, such as perfumes; the manufacture of plastics, where clarity and absence of discoloration are of paramount importance; the alcoholic beverage industry; tanks and tank cars handling glycerine.

In addition to corrosion resistance, ease of fabrication and erection, aluminum alloy storage tanks, piping, stills, filters, condensers, condenser tubing, and shipping containers often have special advantages for processing materials. Aluminum is non-sparking and does not stimulate decomposition of organic liquids.—ALL.

**Hue Variations Caused by Monel Metal.** W. ARMFIELD, *J. Soc. Dyers Colour-*

*ists*, 64, No. 7, 252 (1948).

Investigation of considerable differences in tone experienced on viscose rayon in the course of certain laboratory dyeings indicated that the variations occurred when Monel metal beakers were used, although only some beakers appeared to produce the effect, there being no variation when new beakers were employed. In view of the extensive use of Monel metal in dyeing operations it is suggested that the phenomenon should be of considerable interest.—MA.

## CONDENSATE WELL

**Present Day Aspects of Condensate Well Corrosion.** HARRY E. WALDRIP. *Corrosion*, 4, 611-617 (1948) Dec.; discussion, 617-618.

Discusses classification characteristics, methods of detection, costs, and methods of prevention.

**Prevention of Corrosion in Sour-Wells with Organic Inhibitors.** W. F. GROSS AND H. W. ANDREWS, Petrolite Corp., Ltd. *Oil Gas J.*, 47, No. 26, 76-79 (1948) Oct. 28.

Discussion of investigation of control of corrosion by insulating metal surface from corrosive fluids presents results of field tests of four commercial organic corrosion inhibitors in sour, West Texas oil wells. Kontols 116 and 118 were effective in inhibiting corrosion due to sour crudes. Kontols 110 and 115 were effective to limited degree, although they were effective in

preventing distillate-well corrosion. No preparation of sub-surface well equipment is necessary before starting treatment with Kontol. Protection diminishes gradually for several weeks after treatment stops. Polished rods brighten and paraffin deposition on coupons decreased. Kontols 116 and 118 eliminate tendency to pitting. Results are tabulated, well by well, and are shown photographically.—INCO.

## CONSTRUCTION MATERIAL

**Titanium and Zirconium: New Metals in Australian Metallurgy.** H. W. WÖRNER. *Chem. Eng. Mining Rev.*, 40, No. 7, 254-262 (1948).

The properties, present uses, and possible future uses of the metals and their alloys are discussed, and recent overseas developments are mentioned.—MA.

**Les Nouveaux Alliages Al-Mg-Zn à Hautes Caractéristiques Mécaniques: Le Zircal (New Heavy-Duty Aluminum-Magnesium-Zinc alloys: Zircal).** Pierre Vachet, La Cie Alais, Froges et Camarque, Chambery, France, Labs. du Service des Recherches et Essais Physiques.

A family of aluminum-magnesium-zinc alloys have been produced in France for aeronautical use under the following designations: Zircal (A-Z8GU), Super Alumag T 45 and T 60, and Strongal. They can reach elastic limits of 45-50 kg and 55-60 kg per sq mm in the sheet and wire forms, respectively, and have a fatigue limit

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of 17 kg per sq mm. The characteristic values of the elastic and fatigue limits for aluminum-copper-magnesium alloys are only 32-38 kg and 14 kg per sq mm respectively. The Zical type alloys, are more difficult to work than the latter.

The optimum composition for Zical is 7-8.5% zinc, 2.5% magnesium, 1.5% copper, and 0.25% chromium. The chromium causes a smaller increase in strength but produces better stress corrosion resistance than an equal amount of manganese.

Zical corrodes even when plated unless it is either protected by an anodic coating or made resistant by a proper thermal treatment. The latter should include heating 10 min. in a salt bath, 4-hr. tempering at  $465 \pm 30^\circ \text{C}$ ., and annealing 5 hr. or longer at or above  $135^\circ \text{C}$ . Shorter annealing at lower temperatures makes the alloy susceptible to intercrystalline corrosion. Tables, diagrams.—DPA.

#### Cutting Tool and Die Materials. *Steel*, 123, No. 14, 84-86 (1948) Oct. 4.

Table listing factors to be considered in quick selection of tool steels and carbide types to meet any requirement. Sources, trade names and applications are given as well as data on chemical analyses, heat treatments, quenching media, movement in hardening and machinability as annealed.—INCO.

#### Construction Materials for Jet Pumps. M. RICHELSON. *Chem. Eng.*, 55, No. 9, 114-117, 248-252 (1948) Sept.

A survey, with tables indicating behavior of materials in various media.—BNF.

#### The Effect of Various Treatments on the Stresses in Glass-To-Metal Seals. G. D. REBSTON, British Thomson-Houston Co., Ltd., Rugby, Eng., Research Laboratory. *J. Sci. Instruments*, 25, 138-140 (1948) Apr.

Reliable estimates of the sum of the radial and circumferential stresses can be obtained by sighting along the axis of a cylindrical glass-metal seal. The retardation observed is taken as a direct practical indication of stress magnitude, since most commercial glasses have similar photoelastic constants. The theoretical temperature dependence of the stresses on differential thermal expansion is verified experimentally.

Stress in nitrogen-annealed seals is independent of the amount of metal oxidation produced in making a seal. If the metal is further oxidized after the glass has become rigid, the accompanying changes in volume of the bond cause considerable modification of the stress. On C 53 glass-to-tungsten seals held in air somewhat below the glass-annealing range of  $550^\circ \text{C}$ ., stresses increase rapidly until the seals crack.

Seal oxidation affects the stress temperature curve: at temperatures where glass is rigid, the growth of oxide at the interface initiates a change in stress which is irreversible with temperature and independent of any change in differential contraction; as cooling proceeds, the oxidation rate diminishes until it is negligible, and the retardation curve then is parallel to that in inert atmospheres. The seal stress at room temperature therefore consists of the sum of the differential contraction components, usually radial tension, and the stress due to oxide growth during cooling, i.e., radial compression. The oxide thickness in the original seal does not affect the

room-temperature stress unless it is thick enough to alter the over-all expansion or elasticity of the metal.

Seals of alkali-free aluminosilicate glasses C 53 and C 46 to tungsten and molybdenum, respectively, show relatively negligible changes of stress after repeated cycles for 8 hr. at  $61^\circ \text{C}$ . and 16 hr. at room temperature, both in a humidity room maintained at 95% RH. In comparison, alkali borosilicate-to-tungsten seals (oxide yellow) showed irregular and striking stress reductions after a few hours. This change in stress suggests that the bond is attacked by moisture and swells sufficiently to affect the usual radial tension, even reversing it. Since alkali-free glasses do not show this phenomenon the attack may depend on the presence of alkali tungstate in the bond. Illustration tables, diagram.—DPA.

#### Rating Dynamic Dehumidification Equipment. Pennsylvania State College, Engineering Experiment Station, Technical Paper No. 30. E. R. QUEER AND E. R. McLAUGHLIN. *Heating, Piping, Air Con.*, 19, 103-108 (1947) Jan.

Corrosion of equipment on inactive naval vessels has been prevented by maintaining an atmosphere of 30% relative humidity within the ships. Capacity and performance of specific dynamic dehumidifiers can be controlled by two different test methods. The test equipment is described and performance data are included on typical single and dual bed dehumidifiers.

The rate of moisture removal when air was circulated through the humidifier at specified conditions was determined from the slope of a curve obtained by plotting the amounts of moisture adsorbed against time, using frequent intervals. The moisture was determined from differential weight measurements of the entire dehumidifier before and after water adsorption. A precision indicator with an accuracy of 0.1 lb. was attached to platform scales since the equipment weighed about 1500 lb. and the amount of moisture adsorbed during one operating cycle was about 10 lb. This assured both a constant tare weight and the return of the scale platform to a constant level for each observation.

An alternate method was employed to check the rate and amount of moisture which was removed; it used psychrometric readings obtained from the inlet and outlet air streams and required a complicated technique and calibrated equipment. Using dual bed humidifiers, values were about 3.5-5% lower than those obtained from direct weight measurements, probably due to leakage into the reactivation circuit. Dehumidifiers using activated alumina or silica gel were tested at 0, 40, 70, and  $95^\circ \text{F}$ . and 15, 35, and 75% relative humidity. An increase of the dry bulb temperature for a given entering moisture content reduced the performance of the unit. Dehumidifying equipment using other than solid adsorbents were also employed with only slight test modifications. Illus. table, diagrams.—RPI.

#### Farris Introduces New Pinch Valve. *Paper Trade J.*, 126, No. 17, 49 (1948) April 22.

Pinch Valve for controlling flow of highly abrasive and corrosive materials through a line made of Type 416 stainless steel. Smooth bore minimizes incrustation and permits easy cleaning, while the valve absorbs vibration. It

can be placed in throttling position without undue cavitation or wire drawing. Illustrated. Manufactured by Farris Eng. Corp.—INCO.

#### Corrosion-Resistant Monel-Metal Valves. THEODORE R. OLIVE. *Chem. Eng.*, 55, No. 1, 156 (1948).

Valves available in Monel metal are described.—MA.

#### Iron, Mild Steels, and Low Alloy Steels. R. B. MEARS AND S. C. SNYDER, Carnegie Illinois Steel Corp. *Ind. Eng. Chem.*, 40, No. 10, 1798-1800 (1948) Oct.

Literature review of carbon steels, nickel-steels, low chromium-alloy steels, and low alloy steels. Bibliography of 30 references.—INCO.

#### Moulds for Pre-Cast Concrete. *Light Metals*, 11, No. 129, 549-564 (1948) Oct.

The use of aluminum moulds and pallets for all types of concrete casting in Great Britain goes back about 30 years. In the 1920's one manufacturer found that a reaction occurred between the surface of the aluminum moulds and the lime in the cement, while another firm used aluminum moulding plates for over 25 years and found them entirely satisfactory. The most convincing evidence from the point of view of long-term use is the bus-stop aluminum post produced for the London Transport executive. These moulds are still in service and except for a period during the war when they were stored with a coating of grease over the surface, they have been in almost continuous use since they were first installed. Their present condition is entirely satisfactory.

Present day uses for moulds include slabs and pillars for the "Airey" house, moulds for pre-stressed concrete, pile shuttering, moulds for pipes, etc., pallets for tile manufacture.

It has been suggested that oiling of aluminum moulds and pallets is essential if all action of the alkaline cement on the metal is to be prevented, and further, that aluminum-base alloy castings used for moulds, etc., should be pre-treated with oil in the foundry. Where white concrete work is being produced, oil cannot be used. When the surface of an aluminum mould is protected so that the cement does not make actual contact with the aluminum, no trouble is experienced. One manufacturer states that successful use lies in the fact that he paints the surface of the pallets before they are put into service. A protective film of paint applied to the aluminum surface will permit the gradual formation of a permanent and natural film which under normal conditions will protect the aluminum from attack for an indefinite period. It has been found that such reaction as may occur between aluminum and cements is less in the case of Cement Fondu than for Portland cement.

The special advantages aluminum has over timber for moulds are that there are longer life, no maintenance costs, and they can be used for steam curing and have lower percentage of scrap.—A.I.L.

#### Directory of Materials. *Mach. Des.*, 20, No. 10, 223-290 (1948) Oct.

Listed are materials by trade names, standard stainless steels, with trade names and producers, index of materials by type and materials producers.—BLR.

#### 13th Chem. & Met. Report on Materi-

als of Construction. *Chem. Eng.*, 55, 97-128 (1948) Nov.

Presents, for each of 17 common materials used in chemical industry, a concise summary of good, up-to-date practice in the selection of construction materials. Flowsheets show the process for production of each chemical with materials of construction of each piece of equipment identified. Also includes a 13-page directory of corrosion-resistant materials of construction, giving trade name, manufacturer, composition or description, and most important applications. Includes metals and alloys; carbon and graphite; cement, mortar and putty; ceramics; plastics, and rubbers. —BLR.

**Chemical Engineering Materials of Construction.** *Ind. Eng. Chem.*, 40, 1773-1936 (1948) Oct.

Second annual review series covers literature published since preparation of the first survey. An extensive, documented tabular section immediately following the review articles summarizes important published information on physical and chemical properties of chemical-engineering materials. The articles are as follows: "Aluminum Alloys," Robert H. Brown and Ellis D. Verink, Jr.; "Cements," C. R. Payne; "Ceramics," John H. Koenig; "Copper, Wrought and Copper-Base Alloys," C. Lawrence Bulow; "Elastomers," Harry L. Fisher; "Fibers," Robert S. Casey and C. S. Grove, Jr.; "Iron, Mild Steels, and Low Alloy Steels," R. B. Mears and S. C. Snyder; "Nickel and High Nickel Alloys," W. Z. Friend; "Plastics," Gordon M. Kline; "Rubber, Hard," Frank S. Malm; and "Steel, Stainless and Other Ferrous Alloys," Marshall H. Brown and William B. DeLong. 1463 ref.—BLR.

**Flexible Duct Connectors Exposed to Corrosive Fumes.** *Heat. and Vent.*, 45, No. 3, 108 (1948) Mar.

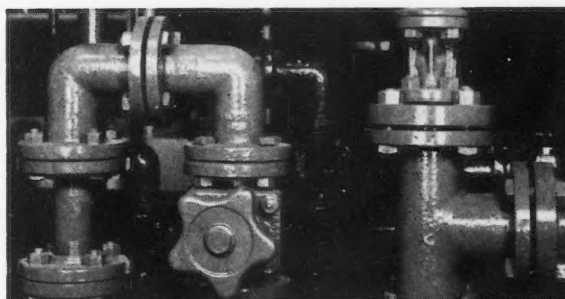
Long life for flexible duct connectors exposed to corrosive fumes advanced by use of Fiberglas-backed industrial adhesive tapes, i.e., a double coated tape on upper and lower flanges of connection between sulfuric acid fume exhaust and stack, with a sealing of rubber-coated Fiberglas and single-coated adhesive tape completing seal. Pictures show application.—INCO.

**Primary Batteries Using Magnesium.** R. FICHTER. *Chimia (Switzerland)*, 1, No. 7, 141-146 (1947) July 15th. *Light Metals Research (England)*, 9, No. 19, 485-6 (1948) Sept. 22.

The author explains the electrochemical principles that suggest the advantages of using magnesium as the negative electrode of a primary cell, particularly in place of zinc. In the case where the carbon electrode surrounded by the usual manganese dioxide-carbon dolly as depolarizer is retained, the cell voltage with magnesium is 2.2 volts as compared with 1.5 volts with zinc. The theoretical capacity of the cell with magnesium amounts to 4.8 WH per g., which is four times the capacity of the zinc-carbon cell. The lower weight of the battery when magnesium replaces zinc is also of advantage in many applications.

The first suggestion of using magnesium in a primary cell dates back to 1887. Subsequent suggestions, mostly in the form of patent specifications, are reviewed, concluding with an account of

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recent developments, notably wartime developments in America, such as, for example, the magnesium-silver chloride-silver battery developed by Burgess Battery Co. The Dow Chemical Co. has patented a cell comprising magnesium and carbon electrodes with a chromic acid electrolyte, while a cell capable of regeneration and consisting of magnesium and lead salts (sulphate or halide) with a neutral salt electrolyte, has been described in a patent by the Compagnie Generale d'Electricite.

The author then goes on to deal with the experiments carried out by the Aluminum Industrie A.G. (Chippis) at its Research Laboratories in Neuhausen, with a view to developing a magnesium battery. Retaining the conventional carbon electrode surrounded by the manganese dioxide-carbon depolarizing mixture, it was found that a sodium persulphate electrolyte gave good results, both from the point of view of cell voltage and absence of any undue attack on the magnesium when the battery was not being used. Corrosion of the magnesium in the idle cell was still further reduced by the addition of dichromate to act as an inhibitor and of sodium hydroxide to reduce the acidity of the solution. The composition recommended is: 20% sodium persulphate, 6% sodium sulphate, 0.2% sodium hydroxide and 0.5% potassium dichromate. The solution tends to decompose when heated, and heating, e.g., when adding starch to thicken the electrolyte, should therefore be avoided.

In view of the difficulty of working pure magnesium, the battery containers were made of Mg-6% Al alloy. Slugs of this alloy can be impact extruded without pre-heating, on the same press as used for the production of the zinc battery containers. An interesting observation was that the corrosion resistance of the magnesium containers could be increased while at the same time raising the cell voltage by surface treating the containers in one of the well-known dichromate-nitric acid baths. The containers are given an outside coating of synthetic resin varnish as a protection against the effects of possible pitting and local perforation. Batteries prepared as described above had an open-circuit voltage of 2.6-2.7 volts. The performance in respect of output of a two-cell magnesium battery of this type was found to be equivalent to that of a three-cell zinc battery under comparable conditions of use.—ALL.

**Stainless Steel Wheel Treads.** *Eng. Mining J.*, 149, No. 6, 108 (1948) June.

Stainless steel treads are mounted on mine wheels to prevent corrosion by acid mine water. Flanges and treads of conventional wheels which are corroded are turned down on a lathe and stainless steel treads are shrunk on. Wheels last four times as long.—INCO.

**The Effects of Electrolysis Upon the Strength of Reinforced Concrete.** *Engineering*, 166, 453-454 (1948) Nov. 5.

Describes and illustrates results of experimental work on the corrosion of steel reinforcing rods in concrete and on deteriorative effects on the concrete itself caused by stray currents from electrical machinery. (Based on work by the U. S. Bureau of Standards and by the British Electrical and Allied Industries Research Assn.)—BLR.

**Full Measure Obtained.** *Die Castings*, 6, No. 4, 25-26, 57 (1948) April.

Rockwell-Emco No. 00 gas meters uses die cast aluminum for housing and valve plates. Alcoa alloy No. 13, with 11-13 silicon, was used because of its high corrosion resistance. Extensive salt spray and thread stripping tests were applied before the meters were used.—INCO.

**All-Bronze Plug Valve.** *Corrosion and Mat. Protection*, 5, No. 5, 16 (1948) Sept.-Oct.

Corrosion resistant all-bronze plug valve is designed primarily for breweries and process industries. According to maker, it prevents contamination of liquids, is strong and durable, and will not leak as standard non-lubricated design. Of corrosion resistant materials throughout, it has no resistance to flow when open, no turbulence, is self-cleaning and easy to operate. mfd. by Ampco Metal, Inc.—INCO.

**New Glass Tank Refractories Step Up Corrosion Resistance.** *Ceram. Ind.*, 51, 75-76 (1948) Dec.

Describes and illustrates performance of Monofrax K, H, and MH, new fused cast compositions recently announced by Carborundum Co. Several characteristics common to this group are a high alumina content, resistance to vertical and horizontal joint corrosion, and a negligible percentage of glassy matrix.—BNF.

**Aluminum Alloys in Materials of Construction.** R. H. BROWN AND E. D. VERINK, JR. *Ind. Eng. Chem.*, 40, No. 10, 1776-1777 (1948) Oct.

Because they do not discolor many chemicals, aluminum alloys are employed for many chemical products for which water-whiteness is a desirable property. Thirty-six 8,000 gallon capacity tank cars constructed of 61S-T4 with heating coils of the same alloy to facilitate unloading, are now in service for the shipping of synthetic glycerol. Aluminum tanks are used for the storage of molten phthalic anhydride produced from petroleum o-xylene, and for shipping ammonium nitrate fertilizers. Aluminum drums of 30-gallon capacity are being used to ship strong concentrations of nitric acid. Storage containers for 90% hydrogen peroxide are made from 99.6% aluminum, and pumps, piping, and heat exchangers for this product are usually made of aluminum. Air-nitrogen and air-nitrogen-oxygen reversing heat exchangers, shell and tube-type exchangers, as well as low pressure towers used in the preparation of oxygen by low pressure fractionation of air, are of all-welded aluminum construction. Aluminum is one of the most suitable materials for equipment used to process vegetable oils and for producing chemicals by micro-biological processes because of its non-toxicity. It is also being used in the production of powdered milk. Other recent applications include aluminum beer barrels and tanks for storing sour crude oil.—ALL.

**Jet Engines Protected by Aluminum.** *The Alcan Ingot* (publication of the Aluminum Company of Canada, Canada), 7, No. 20, 3 (1948) Oct. 22.

Designed and engineered to Navy specifications by the Edo Corporation of College Point, New York, the new jet engine container is made almost entirely of aluminum, and consists of three

basic elements: an engine stand, a moisture barrier to prevent corrosion, and an elastic cage to prevent damage in handling. It has built-in "shock-absorbers" capable of reducing an exterior load to an impact load on the engine itself by a factor of six. The horizontal aluminum member bends when the container is subjected to severe jolts and stresses.—ALL.

## FUNDAMENTALS

**Contribution to the Theory of the Electropolishing of Metals.** (In Russian.) G. S. Vozdvizhenskii. *Zhurnal Tekhnicheskoi Fiziki* (Journal of Technical Physics), 18, 403-406 (1948) Mar.

Critically analyzes existing theories. The solution of the active elements of the surface of the polished metal is believed to be the main factor involved. 11 ref.—BLR.

**A Theory of the Oxidation of Alloys. I.** A. Smirnov. *Acta Physicochim. U.R.S.S.*, 22, No. (1), 162-186 (1947). (In English).

A mathematical treatment of the oxidation at high temp. of a binary alloy. A number of simplifying assumptions are made, e.g., that the metals concerned form a continuous series of solid solutions, that only one type of oxide forms on the alloy, that the film grows only by diffusion of metal outwards and not oxygen inwards, and that the composition of the oxide does not vary with time. The principal feature is that the diffusion coefficients of the metal atoms are considered to be dependent on composition of the oxide. The results predict composition of the oxide will change with distance from the metal-oxide interface, and that with increasing time of heating the concentration of atoms of the metal forming the lattice of the oxide approaches a theoretically determinable limiting value which depends on the composition of the alloy and the temperature of heating. The detailed predictions of the theory are discussed in terms of experimental results for the following alloys: iron-aluminum, copper-zinc, copper-aluminum, and copper-beryllium.—MA.

**Overvoltage of Hydrogen on Powdered-Iron Electrodes.** (In Russian.) S. A. Rozentsveig and B. N. Kabanov. *Zhur. Fiz. Khimii* (Journal of Physical Chemistry), 22, 513-520 (1948) Apr.

The above was determined in 5 N sodium hydroxide. The slope of the overvoltage curve varies with degree of oxidation of the iron surface. An anomaly in the overvoltage curve at low current densities is explained. 11 ref.—BLR.

**Theories Concerning the Passivity of Metals.** (In French.) R. Piontelli. *Metaux & Corrosion*, 23, 124-135; discussion, page 134 (1948) May.

Presents results of a theoretical study of the above, including effects of a series of pertinent factors. Indicates that the phenomena should be studied from thermodynamic, kinetic, and structural points of view.—BLR.

**A Theory of the Formation of Oxide Films on Alloys. II.** A. Orlov and A. Smirnov. *Acta Physicochim. U.R.S.S.*, 22,



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No. 2, 225-237 (1947). (In English.)

Further mathematical treatment of the theory. In Part I a special case only was discussed, but in Part II the general case is considered. The influence of temp. on the rate and character of oxidation is explored, and it is claimed results are confirmed by experimental data.—MA.

**Influence of Low Temperatures on the Mechanism of the Austenite-Martensite Transformation.** Josef Mazur. *Nature*, 162, 184-185 (1948) July 31.

Outlines results of systematic investigations by X-ray diffraction methods of the influence of low temperatures on the lattice parameter of austenite and martensite and on the axial ratio  $c/a$  in martensite using two plain-carbon steels containing 0.89 and 1.2% carbon, respectively.—BLR.

**Corrosion of Metals with Oxygen Depolarization.** *Light Metals*, 11, 503-509 (1948) Sept. (Concluded.)

Final installment of condensed translation of Russian book by N. D. Tomashoff (Academy of Sciences of the USSR) considers the application of polarization curves to the study of corrosion of metals.—BLR.

## INHIBITORS

**Inhibiting Corrosion in Packaged Goods.** *Electroplating*, 1, 533-534 (1948) Aug.

Describes a newly-patented method of preventing corrosion during transport and storage.—BLR.

## INSPECTION

**Thickness Gauge.** *Petro. Ref.*, 26, No. 11, 237 (1947) Nov.

A precision instrument for measuring corrosion and wall thickness from one side of metallic surfaces is announced by Scott Electroflux Co. Electroflux is designed for the non-destructive inspection and testing of metallic containers, vessels and piping while in service. It measures thickness within 3 percent of actual thickness, is portable, and weighs 55 pounds.—INCO.

**Steel Cables—Their Inspection.** (In Portuguese.) Jaao Gustavo Haenel. *Boletim da Associacao Brasileira de Metas*, 4, 99-111 (1948) Jan.

Different types of corrosion affecting steel cables are described and illustrated. Methods for preventing or minimizing them are proposed. 12 references.—BLR.

**Report of Committee A-5 on Corrosion of Iron and Steel.** ASTM, Preprint No. 3, 21 pages (1948).

Includes recommendations for revisions of standards; report of Subcommittee XIV on inspection of black and galvanized sheets (atmospheric tests); report of Subcommittee XV on field tests of wire and wire products; and report of Subcommittee XVI on field tests and inspections of bare and metallic-coated hardware, structural shapes, plates, bars, and their products. Data are tabulated.—BLR.

## METAL FAILURE

**High-Temperature Corrosion of Stainless Steels.** W. E. Fontaine. *Metal Prog.*, 54, 332-336 (1948) Sept.

Design and specifications for parts of a gas-turbine locomotive, fired with high-sulfur bituminous coal, required some specific information on the resistance of standard types of high-chromium and chromium-nickel-iron alloys (stainless steels). Tests at 2000° F. showed that 25% chromium was necessary to prevent more than superficial oxidation in 150 hours, but it was judged that the alloys studied had little structural value for continuous service at such extreme temperatures.—BLR.

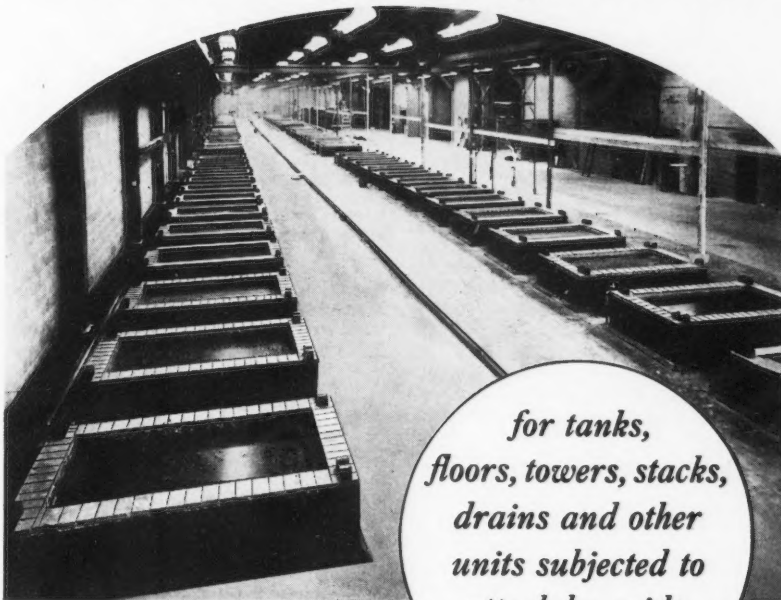
**Shot Quality; How It Affects Fatigue Life.** F. P. Zimmerli. *Steel*, 123, 126-129 (1948) Oct. 18.

Presents results of an investigation to discover how shot hardness affects endurance limit of shot-peened helical springs. Five lots of white-iron shot and one of steel were used. Results are tabulated.—BLR.

**Durability of Aluminum: Misconceptions About Corrosion.** Frank G. Woolard. *Times Rev. Ind.*, 2, No. 16, 21-22 (1948).

There is some misunderstanding regarding the ability of aluminum and its alloys to resist corrosion. Chemically, the alloys are among the more durable metals. Contact insulation and protection for service in the open-air are discussed.—MA.

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**Stress Corrosion Cracking of Mild Steel.** (In French.) J. T. Waber and H. J. McDonald. *R. de Metallurgie*, 45, 93-104 (1948) Mar.-Apr.

Reviews previous theories of the above and presents a theory according to which it is caused by the continuous and combined action of precipitation and stress in accordance with a definite cycle. An important result deduced from the theory is that dissolved nitrogen is responsible for the cracking of steel. Data from the literature which support the theory are charted and tabulated. 19 ref.—BLR.

**Scale (Iron Oxide)—A Discussion of Little-Known Facts About Scale.** W. Trinks. *Ind. Heat.*, 14, No. 10, 1601-1602, 1604 (1947) Oct.

Scale formed on iron or steel when heated in a furnace occurs even when there is no free oxygen in the furnace.  $\text{CO}_2$  produces as much scale as free oxygen does and water vapor produces scale much more rapidly. The reason for this difference in scaling action is dissociation, and because of dissociation is a function of the frequency and velocity of collision of molecules, scaling grows more rapidly than temperature. Scaling is purposely brought about in pit furnaces wherever surface blemishes or small blowholes which are under the original steel surface are to be removed. If scaling is to be reduced to a minimum, steel exposed to products of combustion must lie in a quiescent atmosphere and receive heat by radiation. If it is to be eliminated altogether, a prepared atmosphere is used containing neither oxygen nor water vapor. At the hot end of a continuous pusher-type furnace scale protects the steel from being over-heated. Thickness is a factor considered when wishing to produce a scale which sticks tightly during the processing of steel.—INCO.

**The Mechanism of Exfoliation of Electrodeposited Surfaces.** A. T. Steer. Paper before Electrodepositors' Tech. Soc., 3rd Internl. Conf. on Electrodeposition, London, 17-20, 1947. *Proc., 3rd Internl. Electrodeposition Conf.*, London, 1947, 165-177. Electrodepositors' Tech. Soc., Sept. 17-20, 1947, reprint No. 20, 13 pp.

Discussion of nature of polished metal surfaces, appearance of flow layer illustrated by photomicrographs, including stress exfoliation, influence of stress and corrosion, and exfoliation of lead-bearing brasses. Presence of pinholes provides a line of easy approach of corrosive liquids or gases. Twenty-seven photo-micrographs show flow layer on hard chromium-plated surface on carburized-nickel-chromium-molybdenum alloy, stress exfoliation of bright nickel plate, exfoliation due to flow layer and stress corrosion on crazed chrome deposit and dull nickel plate, section through corrosion spot on dull nickel deposit with decorative chrome layer, erosive nature of attack on nickel, sub-surface cracking in a carburizing nickel-chromium alloy steel, surface of nickel-chromium-molybdenum steel, among others which cover brass, spongy nickel, and pitting.—INCO.

**Materials Handling and Storage of Light Alloys.** James Erickson. *Light Metal Age*, 7, No. 5/6, 10-14 (1948).

The possible causes of deterioration of wrought aluminum alloys are enumerated, and methods of protection during

storage, transport, and handling (mainly by the application of protective coatings) are outlined.—MA.

**Pitting of Steel Parts During Barrel Tumbling.** A. L. Simmons. *Metal Prog.*, 54, 349 (1948) Sept.

Considerable difficulty was encountered with the above. As a result of laboratory tests, it was found no pitting occurred in a pH range of 10.4-11.4. This was achieved by use of soda ash.—BLR.

**Further Development of Methods for Increasing the Heterogeneity of Aluminum-Magnesium Alloys in Order to Improve their Stress Corrosion Resistance.** G. Siebel and G. H. Vosskuhler. *Metall* (Germany), Nos. 9-10, 141-146 (1948) May.

An outstanding improvement in the method for increasing the heterogeneity of aluminum-magnesium alloys with a view to retention of hardness and stress corrosion resistance is based on the fact that heterogenizing of strongly cold worked sheet not far below the liquidus and essentially in the region of crystal recovery, is carried out in such a way that only the beginning of recrystallization is evident and the intermetallic crystals of  $\text{Al}_3\text{Mg}_2$  are precipitated in coagulated form. After the resulting recrystallization, in spite of the coagulated precipitation at the grain boundaries and in the crystal, the stress-corrosion resistance decreases, so that from the structural condition conclusions as to stress-corrosion resistance only can be drawn if grain boundaries are connected by a fibrous structure, which usually, but not always, indicates poor stress-corrosion resistance.—ALL.

**Preventing Season-Cracking in Brass Pressings.** J. SCAMMEL. *Machine Shop Mag.*, 9, No. 7, 60-64 (1948).

Season-cracking is a frequent occurrence in thin-gauge brass pressings, and often it does not appear until after a component has been put into use. The test for season-cracking consisted of immersion for a few minutes in a mercurous nitrate solution. From the first tests it was concluded that heat-treatment is effective only in preventing season-cracking if carried out with the part under the same stress as would be imposed in service. The test-pieces were 70:30 cold-rolled brass 0.005 in. thick. Further tests were carried out on samples which were left in a normal atmosphere free from industrial fumes. Three possible remedies suggested are: a) to remove the stress by redesign of the part, b) to remove the stress by heat-treatment, or c) to obviate the tendency by using a brass with lower zinc content.—MA.

**An Observation of Corrosion Cracking Without Stress.** W. D. ROBERTSON AND H. H. UHLIG. *J. of Applied Physics*, 19, 864-865 (1948) Sept.

Illustrates fragments of an  $\text{Mg}_2\text{Sn}$  single crystal after disintegration upon immersion in distilled water or dilute sodium hydroxide. The fracture appears to be an instance of transcrystalline corrosion cracking in the absence of appreciable stress.—BLR.

**The Embrittlement of Chromel and Alumel Thermocouple Wires.** W. I. PUMPHREY. *J. of Iron and Steel Inst.*, 157, Pt. 4, 513-525 (1947) Dec.

An investigation of the surface embrittlement of Chromel-Alumel thermo-

couples heated to temperatures above  $800^\circ\text{C}$ . in uncleaned stainless steel protecting sheaths. Under such conditions and under purely oxidizing conditions Alumel wire suffers more severe attack and exhibits greater embrittlement than Chromel. Embrittlement in the stainless steel sheath does not occur when the sheath is baked for three hours at  $800^\circ\text{C}$ . before use, but reappears if the baked sheath is oiled before testing. Oil or other sulfur-bearing material probably remains in the protecting tube after manufacture and is the cause of the embrittlement. All stainless steel sheaths for use with Chromel-Alumel thermocouples should be cleaned thoroughly before use. Photographs of embrittled wire are given.—INCO.

**Sulphide Penetration in the Carburization of Steel.** A. PREECE AND K. J. IRVINE. *J. Iron & Steel Inst.*, 157, Pt. 3, 336-343 (1947) Nov.

Mechanism of sulfide penetration into steel during carburization was demonstrated by experiments in which suitably coated specimens of Armco iron were exposed to carburizing mixtures of carbon monoxide and  $\text{CO}_2$ . By adjusting the gas mixture in contact with specimens, deep-seated inclusions were converted into manganese sulfide by prolonged treatment at  $1000^\circ\text{C}$ . Results showed interrelated effects between carbon, sulfur, and oxygen which may be significant in segregation and homogenization of steel castings. 8 references.—INCO.

**Measurement of Diffusion of Hydrogen in Steel.** S. S. NOSYREVA, HENRY BRUTCHER (Altadena, Calif.), Translation No. 2135, 1948, 8 pages. From *Zavodskaya Laboratoriya* (Factory Laboratory), 14, No. 3, 307-310 (1948).

Describes investigation of rate of diffusion of hydrogen at room temperature through ferrite, austenite, cementite, martensite, troostite and sorbite. Describes experimental apparatus and procedure, and gives results of experiments. Includes numerical data on diffusion kinetics of hydrogen in Armco transformer steel, 18-8 stainless, and straight carbon steel in various states of heat treatment.—BLR.

**Investigations on Aluminum Alloys of High Strength at Room Temperature.** (Concluded.) B. W. MOTT AND J. THOMPSON. *Metal Treatment and Drop Forging*, 15, 91-105 (1948) Summer.

Describes test on fatigue and stress-corrosion resistance. Discusses microstructures observed. Includes numerous micrographs.—BLR.

**Stress-Corrosion Tests on High-Strength Aluminum Alloy Sheet.** H. L. LOGAN AND H. HESSING. *J. of Res. of the Natl. Bur. of Standards*, 41, No. 1, 69-81 (1948) July.

This paper describes stress-corrosion tests on high-strength aluminum alloy sheet. The materials investigated were 24S-T, aged 0 to 12 hours at  $375^\circ\text{F}$ . ( $176.3^\circ\text{C}$ .) R301-T; bare and clad 75S-T; bare and clad R303-T275; and bare and clad R303-T315 alloys. The materials were exposed unstressed and stressed in tension to three-quarters of the yield strength in a sodium chloride-hydrogen peroxide solution and in a marine atmosphere. The zinc-bearing alloys, 75S-T and R303-T, all were exposed, while stressed by bowing, in a boiling 6 percent sodium chloride solution. Corrosion

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An Interesting Case of Plated Duralu-  
min. (In Czech.) FERDINAND KADLEC.  
*Hutnické Listy*, 3, 205-208 (1948) July.  
Resistance to corrosion of a plated  
duraluminum sheet varied from one side  
to the other. It was found that the sheet  
was a perfect galvanic cell. The copper  
content of one plated layer was higher  
than that of the other, the result being  
polarization and short circuiting of the  
cell by the base metal with a consequent  
rapid deterioration of the anodic side.  
Reasons for the higher copper content  
in one of the plated layers are advanced.  
—BLR.

Corrosion Resistant Materials in Brass  
and Copper Pickling. *Iron Age*, 162, 100-  
101 (1948) Oct. 7.  
Tables describe four plant corrosion  
tests for pickling of brass and copper  
and four for bright pickling of brass.  
Using each test, corrosion rates are  
given for a series of corrosion-resistant  
metals and alloys.—BLR.

Stress Corrosion: Results Obtained for  
Certain Aluminum Alloys. (In Italian.)  
E. HUGONY. *Alluminio*, 17, 225-247 (1948)  
May-June.

Presents results of an extensive inves-  
tigation of the above for alloys of the  
aluminum-magnesium and aluminum-  
silicon-magnesium-chromium types. De-  
scribes and diagrams special test method  
used. Results are charted and illustrated  
by photomicrographs. 70 ref.—BLR.

Effects of Alloying Elements on the  
Microstructure and Properties of Steel.  
J. M. HODGE, Carnegie-Illinois Steel Corp.  
*Steel Proc.*, 33, No. 12, 746-750 (1947) Dec.  
General effects of alloying elements in  
steel are summarized, showing influence

on hardenability and creep strength and  
effect on strengthening of ferrite and  
formation of carbides. Article is con-  
cerned chiefly with transformation phe-  
nomena. These are classified according  
to temperature ranges at which they  
take place and microstructures of typical  
structures are shown. S curves are  
given for a plain carbon steel, SAE4340  
and 2-chromium steel. Transformation  
on continuous cooling and its relation  
to transformation at constant tempera-  
tures is also discussed and a continuous  
cooling transformation diagram shown  
for SAE4340.—INCO.

Contribution to the Study of the High-  
Temperature Behavior of Austenitic and  
Austenitic-Ferritic Steels of the Modified  
18-8 Type. (In French.) J. HOCHMANN.  
*Revue de Metallurgie*, 45, 171-179 (1948)  
May-June.

Results of investigation, which are  
charted and illustrated by means of  
photomicrographs, indicate austenitic-  
ferritic steels are superior as regards  
mechanical strength and freedom from  
sudden failure at elevated temperatures  
(500-600° C.). Also recommends use of  
titanium, tantalum, or columbium as  
alloy additions.—BLR.

The Study of Ferritic and Austeno-  
Ferritic Stainless Steels. J. HOCHMANN.  
Paper before Journees Metallurgiques  
d'Automne (Fall Metallurg. Conf.) spon-  
sored by Soc. Francaise de Metallurgie and  
Comm. Tech. des Etats de Surface, Paris  
(Abs. in French) (1947) 6-10.

Ferritic steels with 20-30% chromium  
show two zones of temperatures which  
severely modify their characteristics.  
Hardening accompanied by increase of  
fragility occurs after prolonged heating  
at 450-500°. Thus, heating four hours at  
450° increases the elastic limit to the  
detriment of the elongation. Hardening  
also occurs at temperatures above 1000°,  
along with great increase in the elastic  
limit to the detriment of the ductility.  
Chromium ferrites treated at these tem-  
peratures become very susceptible to in-  
tercrystalline corrosion. Re-fusion under

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costly replacement and mainte-  
nance *because you didn't* pro-  
vide protection for exposed in-  
stallations and equipment?

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preventing zinc by the Hot-Dip  
Galvanizing process the ravages of  
rust and corrosion can't touch the  
metal because it is *sealed in*. Rust  
and corrosive elements are *sealed  
out*.

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the entire membership at his dis-  
posal. He has the most modern  
equipment and a trained organiza-  
tion that are at your service. For  
membership roster, write The Sec-  
retary, American Hot Dip Galvan-  
izers Association, Inc., First National  
Bank Building, Pittsburgh, Pa.

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vacuum has no influence on the appearance of fragility on heating at 450-500° but it suppresses hardening after heating above 1000° and susceptibility to intergranular corrosion. There is a practical application of the phenomenon of hardening after heating at 450-500°. By adding nickel to chromium ferrites, their structure is transformed to the bi-phased austenite-ferrite. Such alloys, quenched from 1150° for example, and heated several hours at 400-500° show appreciable structural hardening while retaining sufficient ductility.—INCO.

**Polarity of D-C Control: An AIEE Committee Report.** *Elec. Eng.*, 67, 985 (1948) Oct.

Polarity of coil connections is an important factor in preventing coil corrosion. Replies to AIEE questionnaires indicated there was no trouble resulting from coil corrosion when the negative connection was used, while more than 50 percent of the companies using the positive connection reported corrosion trouble.—BLR.

**Wear Resistance of Gray Iron Diesel Engine Liners.** T. E. EAGAN, Cooper-Bessemer Corp. *Foundry*, 76, No. 5, 134-138+ (1948) May.

Important influence of metallurgy on wear resistance of gray iron is discussed. Results are given of actual service tests on different liners of various compositions carried out under the following conditions: bad atmospheric conditions such as dust storm areas in oil fields; varying load requirements; marine service; corrosive fuels. Microstructures are described and illustrated. Most satisfactory iron has a pearlitic structure and Type A graphite and is alloyed with 1.00-1.50% nickel, 0.30-0.40% chromium, and 0.25-0.35% molybdenum.—INCO.

**Formation and Properties of Martensite on the Surface of Wire Rope.** J. H. CORSON. *Wire and Wire Prod.*, 23, 869-875+ (1948) Oct.

Discusses the reason for service-life variations in wire ropes from the viewpoint of the possible presence of martensite. In service, martensite occurs only in the wire crowns of a rope and is associated with abrasion in which frictional heat is generated. Explanations for the fact that wire ropes with higher carbon content break due to martensite formation while others do not are discussed and it is shown that it is caused by variations in the ductility of the martensite with carbon content. Experimental data in support of this theory are presented.—BLR.

**The Effect of Titanium on Nitrogen in Steel.** GEORGE F. COMSTOCK. *Metal Prog.*, 54, 319-322 (1948) Sept.

First, reviews briefly previous knowledge; then presents experimental data which shows titanium has a readily observable effect on the nitrogen in ordinary steel, even when added in much smaller amounts than those used by Zapfee and Sims or Waber and McDonald. Also describes relative action with aluminum and other grain refiners in plain-carbon steels and precautions to be taken when adding considerably higher quantities of titanium to the high-chromium stainless steels.—BLR.

**A Rapid Method for Determination of the Resistance to Erosion by Cavitation.** (In French.) Y. BONNARD AND E. JOSSO.

*Metaux and Corrosion*, 23, 116-123 (1948) May.

Apparatus described and diagrammed consists of a magneto-structure generator of vibrations in the liquids in which the samples are immersed, which simulates the cavitation effect. Typical results for a series of ferrous and non-ferrous alloys are presented.—BLR.

**Development of Cleavage Fractures in Mild Steels.** A. B. BAGSAR. *Trans. of ASME*, 70, 751-777; discussion, 777-809 (1948) Oct.

The susceptibility of several types and thicknesses of mild steel of ship-plate and pressure-vessel qualities and of welds to development of cleavage or brittle fractures has been determined by a new test, termed the "cleavage-tear" test, in which a notched tensile-bend type of sample is used. Effects of notch and coupon geometries, load eccentricity, rate of loading, testing temperature, and of heat-treatments were investigated. Both brittle and ductile fracture were encountered. On the basis of the data presented, reconsideration of present safety factors for monolithic structures is suggested. Other remedial measures for minimizing the damage of cleavage fractures, including modifications in design and material of construction are also suggested. Includes discussion by 12 authors and extensive reply by the author in which much additional data is presented. 29 ref.—BLR.

**Corrosion Fatigue.** *Allen Eng. R.*, 4-5 (1948) Mar.

Typical corrosion-fatigue failure is illustrated in 6¼ in. diameter horizontal pump shaft which broke after running about 20 hours daily for some ten years, carrying stresses described as "moderate." Mechanical properties of steel are given. Characteristics of failure are described. Increased resistance to this form of attack is given by nitriding, nickel plating, or choosing suitable material, e.g., austenitic 18-8 suitably heat-treated.—INCO.

## REFINERY

**Corrosion Reports by Refinery Analytical Chemist. Part II.** CHRISTOPHER A. MURRAY. *Pet. Ref.*, 27, Sec. 1, 111-114 (1948) Sept.

Reports on actual experiences with fireside tube failure in CHP reformer heater; deposit which plugged thermofor catalytic-cracking depropanizer charge condenser; and thermofor catalytic-cracking-unit gas-plant-section corrosion survey.—BLR.

**Prevention of Corrosion in Refinery Heat-Exchanger Equipment.** M. A. FURTH. *Petro. Ref.*, 27, No. 7, 129-134 (1948); and *Petro. Proc.*, 3, No. 6, 349, 351+ (1948).

Presented to the American Petroleum Institute, Division of Refining. The use of various non-ferrous alloys as tube materials is mentioned.—MA.

**Application of Chromium Steel in High Temperature Installations in the Petroleum Industry.** VAN DER HOEVEN, LA HAYE—Hollande. Paper before Journées Metallurgiques d'Automne (Fall Metallurg. Conf.) sponsored by Soc. Francaise de Metallurgie and Comm. Tech. des Etats

de Surface, Paris, Oct. 6-10, 1947 (Abs. in French).

Chromium steels are used in petroleum refining to improve mechanical characteristics as well as resistance to corrosion or scaling. The choice of specifications is delicate, however, because the price varies 50% in relation to the base price for each unit percent of chromium, and also because the improvement of the corrosion resistance is not directly proportional to the chromium content. Several examples are cited where lack of recognition of the latter has led to deceiving results with high chromium contents. Too low content can equally diminish the corrosion resistance. Also the effect of improvement of resistance by chromium, increases with the temperature. To get the best results it is necessary to have a large practical experience in refining based on years of critical observation.—INCO.

**Refinery Tube Failures; Excessive Temperatures Found Chief Cause.** *Petro. Proc.*, 3, 829-831 (1948) Sept.

Based on "Properties of Carbon and Alloy Seamless Steel Tubing for High-Temperature and High-Pressure Service," Technical Bulletin No. 6-E; Babcock & Wilcox Tube Co., Beaver Falls, Pa.

The most common causes of failure, regardless of metal used, were found to be corrosion, scaling, and creep-rupture due to excessive temperature. Summarizes results of practical experience in study of tube failure over a 25-year period. Properties and applications of a series of steels are concisely stated.—BLR.

**Organic Chlorides in Wyoming Crudes Found Cause of Plant Corrosion.** *Petro. Proc.*, 3, 941, 944 (1948) Oct.

Crudes from West Texas, Wyoming, Illinois, Kansas, and Louisiana were studied. Only the one from Wyoming contained appreciable amounts of organic chlorides and these were mainly in the gasoline range between 250 and 350° F. Types of corrosion experienced by different Wyoming refineries, and methods used to prevent it are described. Some of the information was obtained from two recent papers and some by interviewing refinery personnel.—BLR.

## SURFACE PREPARATION

**The Protection and Improvement of Large Metal Surfaces by Chemical Pickling and Lacquering.** FRITZ ZIMMER. *Metallüberfläche*, 1, No. 4, 88-89 (1947).

Describes the application of lacquering machines to the coating of large sheet-metal surfaces of blackplate, tinplate, etc., with synthetic baked-on lacquers.—MA.

**The Pre-Treatment of Zinc Alloy Die-Castings.** M. P. WILLIS. *Prod. Fin.*, 1, No. 4, 14-17 (1948).

A brief survey of pre-treatment methods for zinc alloy die-castings prior to the application of an electrodeposited, chemical, or organic finish.—MA.

**Protective Finishes for Zinc Alloy Die-Castings.** M. P. WILLIS. *Prod. Fin.*, 1, No. 3, 35-37 (1948).

A short survey of immersion chemical treatments, pre-treatments prior to or-

ganic finishing, and the electroplating of zinc alloy die-castings.—MA.

**Anodic Oxide Coatings: The Influence of Sealing Treatments on Protective Value.** L. WHITBY. *Metal Ind.*, 72, No. 20, 400-403 (1948).

W. discusses the various methods of sealing anodic-oxide coatings to enhance their protective properties and describes an investigation into the comparative value of the following methods of sealing carried out on Hiduminium 66: 1) hot water, 2) nickel or cobalt acetate, 3) potassium dichromate and potassium dichromate + sodium carbonate, 4) sodium silicate, and 5) zinc chromate. The specimens were submitted to the action of a 3 percent salt solution in a closed chamber. The increase in corrosion protection resulting from sealing was remarkable. Chromic acid gave good protection compared with unsealed sulphuric acid anodized coatings, but when the latter were sealed their protective value was almost twice that of the chromic acid anodized coatings. Cobalt and nickel acetate solutions were of about equal value and less effective than dichromate sealing. Sealing with sodium silicate solution can be as good as sealing with the cobalt and nickel acetate solutions.—MA.

**New Phosphate Material Used for Wire-Drawing.** *Steel Proc.*, 34, 475-476 (1948) Sept.

Describes use of "Banox," an amorphous metaphosphate manufactured by Calgon, Inc., at Aliquippa Works of Jones and Laughlin. This material per-

mits an increase of 20-25 percent in the speed of drawing fine high-carbon wire.—BLR.

**Electrolytic Phosphating.** RICHARD SPRINGER. *Metalloberfläche*, 1, No. 4, 78-80 (1947).

The advantages of electro-phosphatizing compared with immersion processes are: 1) greater corrosion-resistance, 2) thicker films with a finer grain-size, 3) lower sensitivity to temperature changes, 4) shorter times of treatment, and 5) special suitability for flow production. The methods described in the patent literature, for both cathodic and AC processes, are briefly discussed.—MA.

**Chemical Pretreatment of Metals for Painting.** R. E. SHAW. *Oil Col. Trades J.*, 114, No. 2594, 28+ (1948).

Some notes are given on the pretreatment of steel, zinc and aluminum, with special reference to modern rapid processing.—RCLPI.

**Die Castings Must Be Clean—III.** A. P. SCHULZE. *Prod. Fin.*, 12, No. 12, 40+ (1948) Sept.

In the fabrication of aluminum die castings, the work frequently acquires an adherent black or brownish film during the alkaline treatment. It usually is traceable to solution of the aluminum from the surface, the insoluble alloys remaining. In some instances, the film may be swabbed off in the subsequent rinse, but more generally a nitric acid-hydrofluoric acid dip is required. When preparing aluminum for electroplating, alkaline treatment often is followed by acid-etching or acid-cleaning to promote good plate adhesion. More recently developed surface preparation methods for the electroplating of aluminum are the zinc immersion process which is adaptable to automatic and still-tank plating, bulk or barrel plating, and phosphoric acid anodic process. In the first method an immersion layer of pure zinc is formed on the aluminum surface by treating the work in a sodium zincate bath after cleaning in suitable alkaline and acid pickling solutions. The phosphoric acid anodic treatment produces an aluminum oxide coating that makes possible direct electrodeposition of metallic coatings.

In the surface preparation of magnesium prior to actual application of protective processes or decorative treatments, acid pickling is the final step after cleaning in a suitable alkaline cleaner, chromic acid being most commonly used. After pickling, the parts are double-rinsed in cold and hot water. For mechanically cleaned and unmachined parts an acid dip consisting of nitric and sulphuric acid is used. To improve the corrosion resistance of chrome-pickled magnesium die castings immersion in a solution of potassium or ammonium dichromate is frequently used.—ALL.

**Surface Treatment for Metals Before Painting.** A. P. SCHULZE. *Ind. Fin.*, 24, No. 4, 48+ (1948).

The importance of obtaining good adhesion of paint films on metals is emphasized. Treatment of metals by removal of contamination (e.g., grease, dirt, alkali, etc.), chemical etching or mechanical abrasion (to obtain a "key") and anti-corrosive treatments are discussed. A continuous spray process for phosphatizing steel, aluminum or zinc metal parts is described. The different

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weights of phosphate deposited on metals by a phosphoric acid cleaning bath (5-10 mg./sq. ft.) and a phosphatising bath (100-400 mg./sq. ft.) is pointed out. Phosphatising also may be carried out electrolytically.—RCLPI.

**Electrostatic Descaling for High-Speed Production.** ARTHUR P. SCHULZE. *Prod. Eng., and Management*, 22, 67-71 (1948) Sept.

Describes and illustrates use of the Bullard-Dunn process for scale and oxide removal from ferrous parts on a volume production basis.—BLR.

**Metal Cleaning Processes.** L. SANDERSON. *Chem. Age*, 58, No. 1491, 205+; No. 1495, 3313; No. 1499, 459-61; No. 1503, 613-6; No. 1508, 779-80 (1948).

A review of modern methods of cleaning metals and the types of plant used. Factors determining methods and materials, use of alkaline solutions, varying treatment for special needs, safeguards, tanks, sprays and electrical processes are described.—RCLPI.

**Surface Preparation, Painting and Paint Baking Set-up for (Metal) Screen and Storm Sash.** W. RUDOLPH. *Ind. Fin.*, 24, No. 4, 68+ (1948).

The set-up described includes overhead trolley-carriers, air hoists for dipping batches of steel parts, metal cleaning, Iridite priming, drying oven, dip coating with enamel and drying at 350° F.—RCLPI.

**Surface Treatment of Zinc Die-Castings. (Prometizing).** *Prod. Fin.*, 1, No. 2, 48 (1948).

A very brief description of the process.—MA.

**Degreasing.** *Prod. Fin.*, 1, No. 2, 80-81 (1948).

Note on a degreasing tank. The tank normally is heated by gas and lagged by means of an air jacket and glass silk; agitation is by air jets arranged to give a turbulent bubbling.—RCLPI.

**Anodizing.** *Prod. Fin.*, 1, No. 1, 62-64 (1948).

The Ematal anodizing process based on an oxalic acid electrolyte containing titanium salts, and a new sulphuric acid process in which certain unspecified addition agents have been added to the standard sulphuric acid solution, are described. Opaque and enamel-like pigmented anodic films are said to be produced by the former, and it is claimed the latter forms coatings of high ductility, low porosity and high abrasion resistance.—MA.

**Treatment of Aluminum Surfaces for Improved Paint Adherence.** *Prod. Fin.*, 11, No. 4, 84+ (1947).

Refers to phosphate or chromate treatments which can be applied to aluminum surfaces to improve the adherence of paint subsequently applied.—MA.

**Aluminum Cleaning Methods.** ALFRED H. POPE. *Metal Fin.*, 46, 75-80+ (1948) Oct.

First discusses the problem in general terms; then discusses specific methods (vapor degreasing, solvent cleaning, emulsion cleaning, alkaline cleaners, pickling, and etching). Finally, deals with the following specific problems: cleaning before spot welding; cleaning before electroplating, by zinc immer-

sion; treatment prior to anodizing; treatment prior to burnishing; brightening prior to buffing; cleaning before bonderizing; preparation for porcelain enameling; producing a frosted finish; removal of an applied oxide coating; and removal of welding flux. 12 ref.—BLR.

**Electropolishing as a Practical Method of Finishing.** L. W. OWEN. *Machinist* (Eur. Edn), 92, No. 4, 93-98; No. 7, 182-184 (1948).

Describes the technique of electropolishing and outlines its possibilities and limitations as a practical method of finishing. Discusses qualities of the metal surface, shape of articles to be treated, preparation of surface, nature of the basic metal, applications to specific metals, and the properties of the finished surface.—MA.

**Surface Preparation of Aluminum for Paint Systems.** Northern Aluminum Co. Booklet, 1948, 17 pp.

This booklet deals with the pretreatment and painting of aluminum. It advises against the use of lead compounds or lead or zinc metal or graphite in priming coats, and suggests that the whole paint system should be purchased from one supplier to insure inter-coat adhesion.—RCLPI.

**How to Figure Costs of Painting Steel Water Tanks.** J. M. PERRYMAN. *Plant Eng.*, 1, No. 1, 48-50 (1947); N.P.V.L. Abs., No. 133, 81 (1948).

The importance of using good paint is emphasized. A table permits estimating the amount of paint required for tanks of various sizes. It is suggested that 4½ times the cost of the paint be added to cover labor and incidental expenses.—RCLPI.

**Use of Aluminum (Foil) for Impermeable Coatings for Pipe Lines in Hydroelectric Plants (I).** L. ZARETTI. *Alluminio*, 17, Nos. 1/2, 34-36 (1948).

Reinforced concrete or cement water pipe-lines are lined inside with one or more layers of aluminum foil, applied with a bituminous or resin-base adhesive (total thickness, 1 mm.). Linings are claimed to withstand high hydraulic pressures and chemical attack.—BNF.

**Rid Water of Dissolved Gas to Stop Corrosion.** R. C. ULMER, E. F. Drew & Co. *Power*, 92, 491-2 (1948) Aug.

Water that contains dissolved oxygen, carbon dioxide, ammonia, or hydrogen sulfide may corrode boilers, heaters, pipelines, etc. Deaeration is used to remove oxygen while scavengers such as sodium sulphite, iron compounds, and certain organic substances (not specified) are used to remove traces of oxygen not removed by deaeration. Inhibitors such as nitrates, chromates, etc. may be used to prevent corrosion. Carbon dioxide is also removed by deaeration, while adding an alkali, a complex phosphate, amines, or organic ammonia compounds prevents corrosion from carbon dioxide and carbonates. Corrosion from ammonia is confined to non-ferrous metals. Multiple or fractional distillation is required to remove dissolved ammonia. Acid treatment reduces ammonia corrosion. Deaeration will remove most hydrogen sulfide while an alkali will neutralize the acidic hydrogen sulfide and reduce corrosion. A chart shows the solubility of oxygen in water from 32° to 240° F.

**Refinishing Steel Drums.** W. D. BALL.

*Can. Paint and Var. Mag.*, 22, No. 6, 7-8+ (1948).

Mass production methods for cleaning and repainting oil barrels are described. The outsides are stripped and buffed by revolving against steel brushes in an alkaline solution. The insides are cleaned by flushing with hot alkali solution, or if rusted, by tumbling with special cutting chains inside.—RCLPI.

**Influence of Electrolytic Polishing on Corrosion Phenomena.** E. MORLET AND F. DANIS. Paper before Journées Metallurgiques d'Automne (Fall Metallurg. Conf.) sponsored by Soc. Française de Metallurgie and Comm. Tech. des Etats de Surface, Paris (1947), Oct. 6-10 (Abst. in French).

Electrolytic polishing has considerable influence on the phenomena of corrosion, either of light alloys such as Y-alloy or Zircal, by activating these phenomena and even provoking intercrystalline corrosion, or of alloys of the 13% chromium type by passivating the surfaces without changing the mechanical qualities of these steels. Results are given of six months corrosion tests and fatigue tests of pieces polished both mechanically and electrolytically.—INCO.

**Anti-Corrosive Treatments (for Aluminum and Magnesium).** R. MORDAUNT. *Prod. Fin.*, 1, No. 1, 34-37 (1948).

Some protective treatments for aluminum and magnesium alloys are very briefly discussed.—MA.

**New Water-Shedding Liquid for Drying Metals.** *Monthly R.*, 34, No. 10, 1179 (1947) Oct.

Hydrex is a thin mobile liquid that sheds water from the surfaces of metals. It has very high penetrating power to enable it to displace water blind holes and crevices. After the water has been displaced, the work is removed from the liquid and the solvent evaporates leaving a water-free surface with some rust-inhibiting properties. The liquid is recommended for drying of plated work such as chromium plate, silver plate or cadmium to prevent staining. Spots that normally remain on the work from solids dissolved in the water, such as chromic acid or from the normal solids present in hard water, are removed. The water separates to the bottom of the liquid and can be drawn off periodically. Mfg. by Enthone, Inc.

**Phosphate Films on Aluminum and Aluminum Alloys.** *Metallüberfläche*, 1, No. 8, 193-194 (1947).

A brief review of American processes and applications of phosphatising to aluminum and its alloys.—MA.

**Metal Cleaning.** *Metal Fin.*, 46, No. 6, 113 (1948).

A tabulated data sheet giving the important features of the most widely used metal-cleaning techniques.—MA.

**The Application of Electrolytic Polishing to Ferrous Metallography.** H. J. MERCHANT. *J. Iron & Steel Inst.*, 155, Pt. 2, 179-194 (1947) Feb.

Preliminary experiments on electrolytic polishing were conducted to determine the effects of variable conditions of electrolysis when using Jacques' perchloric acid/acetic anhydride electrolyte. The design of a suitable type of cell was investigated and five different cells were constructed. For ferrous specimens, either iron or aluminum is a suit-



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chloric acid-alcohol mixtures and special applications of electrolytic polishing methods.—ALL.

**New Baby in the Fluorine Family.** *Ind. and Eng. Chem.*, 40, 22A, 24A (1948) Sept.

Discusses properties and potential applications of a number of salts of fluorophosphoric acid, recently made available in experimental quantities. Applications suggested include cleaning of metals, as electrolytic or chemical polishing agents, or in formation of protective coatings on metals, as well as in organic and physiological chemistry.—BLR.

**Metal Surface Preparation for Organic Coatings.** A. GELMAN. *Electroplating*, 1, No. 10, 511-520+ (1948).

A short review of methods for the preparation of light-gauge steel, aluminum, and zinc surfaces prior to organic finishing. Degreasing, mechanical cleaning, acid pickling, and chemical treatments are discussed.—MA.

**Surface Treatment for Magnesium (Die-Castings).** *Die-Castings*, 6, No. 4, 66-67 (1948).

The anodizing of magnesium alloys in a hot saturated solution of sodium carbonate, using a high voltage, is described.—MA.

**Preparing Aluminum for Organic Finishes.** *Die-Castings*, 6, No. 2, 58-59 (1948).

Accounts are given of acid etching, treatment with a phosphoric acid-organic solvent mixture, production of a chemical oxide coating, production of an electrochemical oxide coating, and the formation of a phosphate coating.—MA.

**Flame Conditioning of Structural Steel.** W. E. DEMPSTER. *Can. Paint & Var. Mag.*,

22, No. 6, 10-12+; No. 7, 7-8+ (1948).

Flame conditioning offers an economical and efficient method of preparing steel work for paint, etc., Using an oxy-acetylene flame followed by wire brushing, the surface is efficiently descaled and dehydrated so that painting is effectively carried out within 45 minutes. Oxygen and acetylene consumptions are 0.25-2.5 cu. ft./sq. ft. and the torch speed is 6-30 ft. per minute. The surface is left warm after treatment and it is important that temp. be < 100° F. before painting starts. Other novel applications of the process besides removing rust and paint from steel include the removal of oil paints from concrete, etc.—RCLPI.

**Surface Preparation as a Measure of Preventing Corrosion.** E. DAVENPORT. *Can. Paint & Var. Mag.*, 22, No. 3, 8+ (1948).

A discussion of the various manual and mechanical methods of surface preparation of steel before painting.—RCLPI.

**Pretreatment of Constructional Steel Prior to Painting.** *Verfkroniek*, 21, No. 5, 107-17 (1948).

The composition of mill-scale, methods for its removal and coating with zinc are discussed.—RCLPI.

**Chromate Finishes to Protect Zinc Surfaces.** GEORGE BLACK. *Matl. and Meth.*, 25, No. 4, 113-116 (1947).

The methods of applying the Cronak, Iridite, and Unichrome Dip treatments are outlined, but no bath compositions are quoted.—MA.

**Rust: Can Its Prevention Be Fully Effective?** J. M. BESKINE. *Prod. Fin.*, 1, No. 2, 14-9.

A general article on corrosion prevention stressing the need of good pre-treatments before painting.—RCLPI.

**Fungicides Fungus-Proofing Glue/Glycerol-Bonded Cork Gaskets.** S. BERK. *Ind. Eng. Chem.*, 40, No. 2, 262-6 (1948).

Applying forty fungicidal treatments to protein-bonded cork, it was found that 10 minutes immersion in the fungicide was primarily a surface treatment. Using four test organisms and three methods of incubation, formulations containing 2 percent p-nitrophenol gave complete protection whilst others containing p-n-trophenol with paraffin wax aluminum stearate or salicylanilide and 1.8 percent 3,5-dinitro-o-cresol gave almost complete protection.—RCLPI.

**Surface Finishing of Aluminum and Its Alloys.** Aluminum Development Assoc. *A.D.A. Information Bull.*, No. 13, 43 pp. (1947). *Bull. Brit. Non-Ferrous*, 28, No. 225, 72 (1948).

A comprehensive yet concise account of the processes available, with the exception of the anodic processes, which will be dealt with in A.D.A. Information Bull. No. 14. Specific directions are given (such as solution compositions, treatment temperatures, etc.), and the advantages and limitations of the various methods indicated. Processes covered include cleaning and degreasing; mechanical processes (e.g., polishing, scratch-brushing, pattern rolling); chemical processes (M.B.V. Process, etc.); electroplating and the numerous methods of surface preparation for it; and paint finishes (pre-treatment, priming coats, finishing coats, lacquers, stoving finishes, etc.).—RCLPI.

## TESTING

**Non-Destructive Test Methods, Seven Basic Methods for Non-Destructive Testing of Materials.** B. Carlin. *Product Engineering* 19, No. 7, 129-132 (1948) July.—ALL.

**A New Instrument for Measuring the Flexibility and Adhesion of Surface Coatings.** H. W. Chatfield. *Paint*, 17, No. 9 (1947); and (summary) *Products Finishing* 12, No. 6, 88+ (1948).—MA.

**Modernized Corrosion Testing.** Anon. *Shore and Beach*, 13, No. 10, 38-42 (1948). *Prev. Det. Abs.*, 3, Met. 25 (1947).

An account of the equipment, site and details of practice at Kure Beach (Wilmington, U.S.A.), the largest testing station for marine corrosion and fouling in the world.—RCLPI.

**A Method of Testing the Corrosion Resistance of Gas Appliances.** H. A. Fray, R. S. Peoples, and R. S. Dalrymple. *Gas Times*, 56, 328-330 (1948) Sept. 10.

Gives details of apparatus and procedure developed at Battelle Memorial Institute under sponsorship of American Gas Association. Effects of sulfur content on corrosion of SAE 1010 sheet steel exposed to flue gas under cyclic conditions are outlined. Included charts and diagrams.—BLR.

**Corrosion Stability of Compressed Eloxidised Sheet Metals Made Out of Aluminum Alloys Placed on the Nerdency Low and High Tide Test Stand and in the DVL Alternating Dipping Device.** F. Loipelmann. *Off. Tech. Serv. Report PB*, 38614. *Prev. Det. Abs.*, 4, Met. 12 (1948).

Eloxidised aluminum alloys after-coated with sodium dichromate are recommended for use on airplanes and should be protected, a) if for the interior, by a thin coat of N.C. lacquer at 10-15 g/sq. metre, b) if for the exterior, by a waterproof pigmented N.C. lacquer at 60-70 g/sq. meter.—RCLPI.

**Rapid Test Method for Resistance to Erosion by Cavitation.** E. Josso and Y. Bonnard. Paper before Journees Metallurgiques d'Automne (Fall Metallurg. Conf.) sponsored by Soc. Francaise de Metallurgie and Comm. Tech. des etats de surface, Paris (1947) Oct. 6-10 (Abst. in French).

A vibratory apparatus excited by magnetostriction designed to generate the effects of intense cavitation in liquids and to provoke rapid destruction of specimens is described. Some results are given and seem to show that neither hardness, micrographic structure, or corrosive resistance seem to affect cavitation resistance in a definite manner.—INCO.

**Exposure Testing of Paints.** R. H. Gunning. *Paint Notes*, 3, No. 1, 2-11 (1948).

A review of natural weathering test methods and their limitations.—RCLPI.

**Corrosion Tests in Organic Sulfonates and Sulfonations.** W. Z. Friend. *J. of the Oil Chem. Soc.*, 25, 353-358 (1948) Oct.

Presents results of some plant and laboratory corrosion tests in organic sulfates and sulfonations under a variety of operating conditions as an indication

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of the metals and alloys which should be considered for the construction of processing equipment. Extensive data are tabulated.—BLR.

**Standardization of Buffing for Preparation at Atmosphere Exposure Test Panels.** C. C. Cupps and A. K. Graham. *Proc. Amer. Electroplaters' Soc.*, 276-280; discussion, 295-297 (1947).

The construction and operation of an automatic buffing machine for treating panels 6 x 4 in. are described. Comparative figures are given for the results obtained by this method and those obtained by a carefully standardized hand-buffing operation. Specimens included copper and nickel on steel, and nickel on buffed and unbuffed copper. The machine method gave much greater uniformity than the hand method. The possibility of using the machine as a means of comparing the ease of buffing of different deposits is suggested.—MA.

**Outside Exposure Tests of Paints and Varnishes on Wood.** Commissie Kertingsmethoden Verf. C.I.M.O. Afd. Verf. Circ. No. 40, 6 pp. (1947)

A standardized procedure is proposed for carrying out the tests, covering the types of panels and exposure rack and method of painting and examination. Photographs are included indicating different degrees of cracking, flaking and blistering.—RCLPI.

**The NDHA Corrosion Tester: Why and How It's Used.** Leo F. Collins. *Heat Piping & Air Cond.*, 20, 77-80 (1948) Oct.

Explains the need for studying corrosion rates and the development, features, performance, and uses of the NDHA corrosion tester, which has demonstrated its reliability as a measuring device. Describes and diagrams the tester and method of installation in pipeline and tank systems of various sizes and shapes. It consists of three helical wire coils supported by a frame and electrically insulated from each other and the frame. The coils are specimens whose weight losses are determined.—BLR.

**High-Speed Rotor Tests of Paints for Under-Water Service.** F. WORMWELL, T. J. NURSE and H. C. K. ISON. *J. Iron Steel Inst.*, 160, 247-260 (1948) Nov.

Part I describes apparatus for investigating the corrosion of metals immersed in liquids under conditions of rapid movement. Part II deals with use of the apparatus in testing a series of typical ships' bottom compositions. Parts III and IV describe use of the apparatus in comparing several paints formulated by Fancutt and Hudson. Experimental results are given in Part V. Part VI deals with methods of evaluation of paint failure in rotor tests. Measurements of depth of penetration of corrosion are given for selected paint systems and the results are discussed. The mechanism of blistering, and of paint failure generally, is also discussed. A combination of more intensive conditions of test with more sensitive methods for detecting paint failure is recommended. 17 ref.—BLR.

**Selected Bibliography on Salt Spray Testing.** L. R. VOIGT. *Corrosion*, 4, No. 10, 492-504 (1948).

A classified bibliography with brief abstracts.—RPI.

**Corrosion of Iron by Water-In-Oil Emulsion—Part II. Corrosion of Engines by Emulsions.** L. C. VERMAN AND OTHERS. *J. Aci. Ind. Res.*, 7B, 144-148 (1948) Sept.

Results of accelerated corrosion tests and long term engine trials, which are tabulated, show that sodium nitrite is not suitable for use as an additive. Recommends that 0.5% chromium oleate plus 0.5% Chromium naphthenate be used as additives to lubricating oils for low-temperature internal-combustion-engine operation, and for pumps and compressors to inhibit corrosion due to emulsified oil. 14 ref.—BLR.

**Further Investigations on the Pressure Welding of Light Alloy Sheet.** R. F. TYLECOTE. *Trans. Inst. Welding*, 11, No. 5, 94r-108r (1948) Oct.

Discussion of shear strengths of pres-

sure and spot welds; pressure welding characteristics; effect of oxidation prior to pressure welding; corrosion tests in nitric acid, and in salt spray on welds in aluminum and aluminum alloys; and laboratory experiments on potential applications. Shear test results for corroded and uncorroded specimens are plotted, results of salt spray corrosion tests on pressure welds are tabulated, and penetration along interface near weld after corrosion in nitric acid is diagrammed.—INCO.

**pH Determination in Condensate Well Waters.** D. A. SHOCK. *World Oil*, 128, No. 3, 141-2 (1948) July.

By modifying a standard dew point apparatus, a pressure chamber has been constructed so that the pH of wellhead water can be estimated at wellhead



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pressures ranging up to 4,000 psi. A diagrammatic sketch of the apparatus as developed in the Natural Gasoline Association of America's Corrosion Research Project Comm. is included. The steps in the determination are outlined. The pH is determined by color comparison using various indicators with a pH range from 3.00-6.8. Experiments showed that carbonic acid concentrations are largely responsible for the severely corrosive conditions found in the fields studied. The organic acids seem to have reacted with the tubing by the time they reach the wellhead so that little effect is noted from them when a pH determination is made of the fresh water sample at atmospheric pressure. The water samples showed a definite tendency to decrease in pH value on standing since the iron hydrolyzes and organic acid is freed. The results show why much of the pH data taken on well waters reflect no correlation with the corrosion taking place in the well. The apparatus has been successfully operated in 4 fields, making several dozen determinations without failure on pressures up to 2500 psi. and temperatures to 170° F.

**Discussion on Some Aspects of Corrosion. Iron and Steel Institute and British Iron and Steel Research Association. *Paint Technol.*, 13, No. 153, 360 (1948).**

A report of a discussion, mainly on testing procedures.—RPI.

**Tests on New Paint Inhibitors. Iron and Steel Institute, British Iron and Steel Research Association and others. *Paint Manuf.*, 18, No. 9, 306 (1948).**

Summary of an interim report (6 months' exposure) on 100 priming paints now being tested. The results indicate the importance of film thickness, and that a marine exposure was more destructive than exposure to an industrial atmosphere.—RPI.

## UNDERGROUND

**Los Angeles Program Speeds Reconditioning of Cast Iron Pipe. R. E. HEMBORG, Los Angeles Dept. of Water & Power. *Eng. News-Record*, 140, No. 2, 92 (1948) Jan. 8.**

Cast iron pipe removed from water service is reconditioned by hand-scraping, grit-blasting, mortar-lining and coating with a coal-tar paint to prevent rust and to protect pipe in a moderately corrosive soil.—INCO.

**Prevention of Corrosion and Electrolytic Effects in Underground Conductors. F. GUERY. *R. Gen. Elect.*, No. 10, 401-411 (1947).**

The serious results resulting from the corrosion of underground conductors are discussed; the corroding effect depends on the type of soil. In tramway conductors electrolytic effects are possible owing to circulating currents in the rails. The results of investigations of soil-rail resistances are given, and the theory of the circulation of currents in the lines and the surrounding soil is discussed. The modern theories of corrosion are reviewed, and from them methods of preventing the corrosion are suggested, in particular the avoidance of junctions of dissimilar metals. Cathodic protection is mentioned as a very important remedial measure.—MA.

**Aluminum Pipe Lines for Oil and Gas (Petrol). H. S. BELL AND C. R. HOLMES. *Oil World*, 169-172 (1948) Feb.**

The possibilities of use of extruded aluminum alloy pipe up to 12¾ in. outside diameter are discussed. It is concluded that in the U.S.A. such pipe lines may be laid at a cost comparable with emergency deliveries of steel pipe, and at 30-50% above lines laid with the latter at present mill price. Alloy 61-S (1% magnesium, 0.6% silicon, 0.25% each copper and chromium) is recommended.

**Rehabilitation of Pipe Lines in Place, 3" to 24", by the Pittsburgh-Eric Process. A. B. ANDERSON, Pittsburgh Pipe Cleaner Co. Paper before Pittsburgh Corrosion Forum, Pittsburgh, May 10, 1948. *Corr. & Mat. Prot.*, 5, No. 3, 6-8 (1948) May-June.**

Process is an electrolytic method of depositing an especially prepared bitumen compound from an aqueous solution on pipe interior. Similar in principle to copper or silver plating electrolytic methods with exception that plating material is taken from electrolyte. Developed by Eric Eng. Co. of England.—INCO.

## WATER

**The Promotion and Acceleration of Metallic Corrosion by Micro-Organisms. T. H. ROGERS. *J. Inst. Metals*, 75, No. 1, 19-37 (1948) Sept. Work done by the B.N.F.M.R.A.**

In 1936 the BNFMA began research on the influence of biological factors in the corrosion of condenser tubes, and the author describes some of the more important investigations carried out. (This paper is substantially the same as R.R.A. 779, which was announced to members in March, 1948. Reprints will be available as R.R.A. 779P.)—BNF.

**Trends in Modern Feedwater Conditioning Equipment. Part II. S. B. APPLEBAUM, President, Liquid Conditioning Corporation. *Power Generation*, 52, No. 7, 1-66 (1948) July.**

Three case histories show how selection of feedwater conditioning equipment depends on: 1) the predicted analysis of the treated water to be produced, 2) chemical operating costs, 3) cost of installation, 4) degree of operating skill required, and 5) percentage of boiler blow-down required to keep total solids or silica in the boiler water within proper limits. Consideration of these factors led to selection of hydrogen-sodium-zeolite, sodium-zeolite, and two-stage hot process softening in the three cases cited.

Part I of this article, in the June, 1948 issue of *Power Generation*, discusses prevention of scale, carry-over, corrosion, and silica turbine deposits, and names available methods of external water conditioning.—NALCO.

**An Investigation of Boiler-Drum Steel After Forty Years of Service. H. S. BLUMBERG AND G. V. SMITH. *Trans. ASME*, 70, 185-198; Discussion, 198-200 (1948) Apr.**

Examination of materials from seven riveted boiler drums removed from service after 40 years' operation at a temperature and pressure of 388° F. and 200 psi, respectively, revealed no evi-

dence of deterioration in properties of the steel from which they were made. Includes photomicrographs.—BLR.

**Ion Exchange. R. KUNIN, The Resinous Products & Chem. Co. Chem. Eng. Unit Operations Review. *Ind. & Eng. Chem.*, 40, No. 1, 41-45 (1948) Jan.**

Theory and application of ion exchange is reviewed with 132 references including patents. Water softening, deionization separation and concentration, purification, use in analytical chemistry and for miscellaneous purposes are covered. Standardization of test methods and terminology by the ASTM is recommended.—INCO.

**Symposium on Purification and Conditioning of Water Supplies. *Ind. and Eng. Chem.*, 40, 1350-85 (1948) Aug.**

This 35-page section consists of reprints of the following papers presented before the Division of Water, Sewage, and Sanitation Chemistry at the 112th Meeting of the American Chemical Society, New York, N. Y.:

**Dowex 50—A New High Capacity Cation Exchange Resin. (Stability, properties, field tests) W. C. Bauman, J. R. Skidmore and R. H. Osmun, The Dow Chemical Co.**

**Activated Silica Solutions in Water Treatment. (Types, preparation, coagulation applications, effects). Reynold C. Merrill, Philadelphia Quartz Company.**

**Steam Bubble Formation—Effects of Heating Surface and Use of Anti-foams. Arthur L. Jacoby and Lawrence C. Bischmann, National Aluminate Corp.**

**Polyamide Foam Inhibitors. Mechanism of Foam Inhibition in Steam Generators. (Antifoam preparation and testing, field experience, theory.) L. O. Gunderson and W. L. Denman, Dearborn Chemical Co.**

**Railroad Boiler-Seam Cracking Controlled by Nitrate Treatment. (Embrittlement causes, preventive treatments, embrittlement detectors, nitrate treatment results and cost). A. A. Berk, Boiler Water Research Section, Bureau of Mines.**

**Progress in Railroad Water Conditioning. (Development of softening plants, chemicals used, water testing, Diesel locomotive water treatment). R. C. Bardwell and J. J. Dwyer, The Chesapeake & Ohio Railway Company.**

**Chemical Control at Chicago's South District Filtration Plant. (Description of treatment, chemicals used, laboratory facilities, chemical control). John R. Baylis, Chicago Department of Public Works.—NALCO.**

**Prevention of Turbine Blade Deposits. C. E. IMHOFF, Allis-Chalmers Mfg. Co. Paper before Wis. Power Conf. & Exposition, Green Bay (1948), June 24. *Paper Trade J.*, 127, No. 5, 39-43 (1948) July 29.**

Successful prevention of turbine blade deposits consists in recognition of compounds comprising blade deposits, knowledge of approximate limits of boiler-water concentrations for these compounds, control of these limits by primary or supplementary water treatment, and use of soluble salts having specific inhibitory action. Discussion includes methods of study, X-ray diffraction analysis, characteristics of deposits, deposits of sludge origin, deposits of boiler water origin, prevention of blade deposits, concentration control, operat-

ing limits, solids removal by primary treatment, oil, and added chemicals. —INCO.

**Corrosion and Its Prevention in the Water Cooling Systems of Internal Combustion Engines.** M. A. HANSON, A.C.S. 114th Meet., St. Louis; Abstr. of Papers: 7-8R (1948) Sept. 6-10.

Design changes have resulted in more heat to be dissipated by engine cooling systems and more readily corroded parts. The details of construction of modern cooling systems make the prevention of corrosion difficult since a large number of different metals are used, velocities vary widely, and small intricacies are prevalent. The corrosion experienced may be highly localized or quite general and more or less attack all parts in contact with the cooling water. No water without supplemental treatment is satisfactory for cooling water. Up to the present time low hardness, low total dissolved solids, water with the pH adjusted to the range of 8.5 to 9.5 and with the addition of 1800 ppm of alkaline chromates have been found the most effective and reasonably satisfactory. (Little more information in abstract.)

**The Power Plant, 5 Modern Boilers Will Replace 46 Old Ones in Steel Plant.** F. X. GILG, Babcock & Wilcox Co. *Blast Furnace & Steel Plant*, 36, No. 1, 108-111 (1948) Jan.

At the Southside Works of the Jones & Laughlin Steel Corp., to avoid the erosion of boiler tubes due to impingement, gas baffles are of monolithic construction. Discussion of the water treatment, superheater, boiler and furnace walls and diagrams of various parts are included. —INCO.

**The Corrosion of Zinc and Zinc-Coated Steel in Hot Waters.** P. T. GILBERT, *Pittsburgh Internat. Conf. Surface Reactions (Proceedings)*, 21-48 (1948).

Gives the results of a study of the corrosion of zinc and galvanized steel in a hard supply water and in certain synthetic solutions, at temp. up to 85° C. In the supply water the corrosion is

more highly localized in the hot than in the cold, and a rapid pitting action occurs. Moreover, the potential of the zinc surface as a whole can become so cathodic that it is more noble than steel corroding under the same conditions. Consequently, unless attack is stifled by deposited scale, pits which penetrate a galvanized coating can proceed through the basis steel in hot water. The conditions under which this reversal of polarity between zinc and steel occurs were investigated. By making electrochemical measurements and the usual qualitative and quantitative observations of corroding specimens, a theory of the corrosion of zinc and galvanized coatings is developed. —MA.

**Reasons Why Sulphur Joint Compounds Are Providing a Mystery for Waterworks Engineers.** *Eng. News-Record*, 140, No. 21, 6 (1948) May 20.

Discussion of behavior of sulfur joining compounds in some localities where it was observed that material disintegrates or is believed to cause pitting of spigots and breakage of bells in cast-iron pipe. Difficulties were complete or partial disintegration of sulfur compound, pitting and corrosion of spigot end of pipes, and cracking of bell on pipe. —INCO.

**Questions and Answers — Electrolytic Action in This Boiler?** C. C. CUSTER, *Power Generator*, 53, No. 1, 88-89 (1948) Jan.

Discussion of possible causes for corrosion in a land boiler and remedies for them. —INCO.

**Controlling Impurities in Air Conditioning Water.** R. B. CONLAN, W. H. AND L. D. BETZ, *Southern Power and Industry*, 72 (1948) Aug.

The spray water in an air-conditioning system absorbs from the air such impurities as dust, pollen, molds, and some forms of bacteria. Chemicals used to prevent biological fouling of equipment by these impurities should be non-corrosive, non-volatile, stable and toxic to the organisms while being non-toxic to man.

## CORROSION DIRECTORY

Rates for notices under this heading can be obtained from National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas.

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Advantages and disadvantages of copper sulphate, inorganic and organo-mercury compounds, chlorine, chloramine, phenols and cresols, and potassium permanganate are discussed in this article.—NALCO.

**Galvanic Corrosion in Fresh Water.** C. L. BULOW. *Product Eng.*, 19, No. 8, 43 (1948) Aug.

The article discusses bimetallic systems, as used in contact with hot or cold fresh water. Such uses are found in heat exchangers, condensers, automobile radiators, diesel and gas engine coolers, mercury arc rectifiers, transformers, air conditioning equipment, hydraulic systems, steam generators, locomotives, etc. The article discusses copper galvanically coupled with aluminum, steel, zinc, and magnesium, where increased corrosion of the latter materials may occur. When attack in these less noble metals occurs in fresh waters, the corrosion generally is located near the junction of the two dissimilar metals. This localizing of the corrosive attack is primarily the effect of the relatively high electrical resistance of most fresh waters. At ordinary temperatures, the galvanic corrosion which occurs generally is not severe if the areas exposed are comparable in size.

In some waters, stifling of corrosion may occur because of the formation of various mineral scales of relatively high electrical resistance on the cathodic surface (because of the higher pH which develops on the cathodic surface.) In closed systems, soluble oils, salts and organic corrosion inhibitors are used to reduce general corrosion as well as galvanic corrosion.—ALL.

**Performance of Steam Condensers Aboard U. S. Naval Vessels.** H. E. BETHON. *Corrosion*, 4, 457-462 (1948) Oct.

Based on wartime experience, the author summarizes recommendations for materials and design in connection with the above. Continued use of 70%-copper, 30%-nickel tubes and tube sheets and of Monel water boxes; use of electronically controlled tube expanders for rolling the tubes into the tube sheet; and consideration of the pros and cons of continuing the use of zinc or mild-steel plates when similar materials are used in the hydraulic circuit are among the recommendations.—BLR.

**Water Problems in Diesel Locomotive Operation.** M. A. Hanson, Gulf, Mobile & Ohio Railroad Company American Waterworks Association, *J. A. W. W. A.*, 40, 971 (1948).

Probably the most effective method of combatting the serious problem of Diesel locomotive cooling system scale and corrosion is to employ a water of low dissolved solids content, adjust the pH value to 8.5-9.5, and use an alkaline chromate inhibitor at a minimum concentration of perhaps 500 parts per million.

For controlling scale formation in Clarkson Steam Generators, use of distilled or demineralized water is undoubtedly the most desirable method, the author states, although zeolite, lime-soda or internal treatment fill definite needs. For example, zeolite treatment is satisfactory and may be less costly when the water supply is initially clear and low in hardness and alkali salts.

Deaerated feedwater with pH of 7.5 or above for the steam generators was found to be non-corrosive in tests; without deaeration, feedwater was shown to be corrosive with a pH of as high as

12.5, although promising results in reducing corrosion were obtained on an operating locomotive by maintaining the feedwater pH at a minimum of about 9.8 with internal treatment.

**The Corrosion of High Purity Zinc and Its Alloys.** (In German.) L. W. Haase. *Metalloberfläche*, 1, 73-77. (1947) Apr.

Gives results of investigation of the electrochemical behavior of pure zinc and its alloys for use in water installations. Galvanized coatings for protecting steel are also discussed. Concludes that zinc alloys cannot be substituted for brasses and bronzes in handling water.—BLR

**The Behavior of Metallic Materials in Relation to Very Dilute Aqueous Solutions.** L. W. Haase. *Arch. Metallkunde*, 1, No. 6, 259-264.

H. discusses: (1) the relationship between the composition of the dil. aqueous solution, particularly of sodium chloride, and the progress of the corrosion of iron, (2) the formation and properties of protective films formed on metal surfaces during corrosion, especially the hydroxides formed on lead, zinc, iron, galvanized iron, and aluminum, (3) the corrosive action of natural waters containing alkaline carbonates, and (4) the corrosion of metals by moisture and soils.—MA

**Orientation of Thin Copper Oxide Films on Copper.** (In French.) Henri Frisby. *Comptes Rendus (France)*, 226, 572-573. (1948) Feb. 16.

First, calls attention to a major error in a previous note (v. 224, 1947, p. 1003). Then gives results of a study, by means of electron diffraction, of films formed on copper during immersion in boiling water. Illustrated.—BLR

**High Alkalinity and Organic Material for Sludge Removal.** S. K. Adkins. *Combustion*, 19, No. 10, 38 (1948) April.

Data on the experience with boiler-water problem at South Omaha Steam-Electric Station.—INCO

**Boiler Corrosion and Water Treatment.** Admiralty. *Brochure*, 1945 (published 1947), 33 pp. H.M.S.O. 6s.

Provides descriptions (with numerous illustrations, some in color and theoretical explanations of types of corrosion encountered in service, with suggestions for obviating or minimizing them. Also discusses scale formation; priming; chemistry of distilled water, shore waters and sea water; and chemical treatment of boiler water. Appendices deal with circulation and heat transfer in boiler tubes, etc.—BNF

**Report of (A. S. T. M.) Committee D-19 on Water for Industrial Uses (Corrosion of Metals).** *Amer. Soc. Test. Mat. Preprint*, No. 78, 32 pp. (1947). Progress report.

A proposed tentative practice for corrosion tests (NDHA method) in industrial waters is described in detail. It is particularly applicable for waters (up to 200°C.) relatively free of suspended materials. Three helical coils of wire are exposed for 30 days or until a 10% loss in weight is measured. Particulars of the corrosion rate of 21 non-ferrous and ferrous wires are tabulated.—MA.

**Sulphate-Reducing Bacteria in Industrial Waters: Proposed Tentative Method of Test.** American Society for Testing Materials *A.S.T.M. Preprint* No. 74, 19-28 (1948).

Includes an appendix on proposed

method for identification of types of micro-organisms in industrial waters.—BNF.

**Descaling Tanks by Electrolysis.** *Fairplay*, 170, 990, 992 (1948) Apr.

Oil tankers carrying light spirit are particularly susceptible to corrosion in those tanks in which water ballast is carried on the outward voyage, and, unless the scale formed of corrosion products which results is removed at intervals, the rate of deterioration of the steel is particularly severe. It is stated that for some unknown reason this deterioration has been particularly bad in certain tankers during recent years, in spite of frequent descaling of the tanks. Normally, the scale, which fortunately is not particularly adherent, is removed by scraping, but an alternative process is now available whereby this can be done by electrolytic means. In this method, evolved in the United States during the war, procedure is to deposit on the walls of the tank to be cleaned a thin coating of magnesium salt, which forms beneath the scale or rust and thus loosens it. This is done by filling the tanks with sea water and using a number of carbon electrodes which are placed in the tank. A fairly high current density has to be used, and the time taken for completing the operation depends on the number of electrodes available.—ME.

**Corrosion of Phosphated High-Grade Zinc Alloys by Fire-Extinguishing Liquids.** (In German.) R. Beythien. *Archiv für Metallkunde*, 1, 286-288. (1947) June.

Results of experiments, which are tabulated and shown by means of a series of photographs of test samples, for nine different commonly used fire-extinguishing solutions or liquids, show that, in general, phosphating (bonderizing) gives less effective protection than chromizing. Some bonderized samples were found to be less corrosion resistant than unprotected samples. Use of lacquer coatings is suggested.

The alloys studied were 1) zinc with aluminum 0.2 and copper 4 percent, and 2) zinc with aluminum 15 percent and magnesium 0.01 percent, in corroding media of solutions of various carbonates or in carbon tetrachloride. The protection afforded by chromatization of the metal surface is superior to that obtained by bonderization.

**Apparatus and Factors in Salt-Fog Testing.** V. M. Darsey and W. R. Cavanaugh. *ASTM, Preprint* No. 9, 3-16 (1948).

Describes construction of a salt-fog testing cabinet and discusses effects of the following variables in carrying out the test: pH of the salt solution and effect on it of material of container, volume and pressure used to atomize the solution, the salt-fog collection rate and temperature and specimen position. Corrosiveness was assessed by effect on scratched painted steel panels. The test method B 117-44T are discussed. Air pressure variation greater than  $4 \pm 0.1$  psi give abnormal results.

**Topical Committee on Materials.** G. H. Calhoun. *Proc. Api.*, 27, (IV), 107-116 (1947).

Committee report deals with corrosion of condensate wells; corrosion-fatigue testing of sucker-rod materials; standardization of asbestos-cement pipe and fittings; oil-well cements; corrosion resistance of tubing and casing materials;

August, corrosion rods and terms for Appendix for various condensers companies The S. C. D. (1948) The r were a ments o for unit in com regard oxide, materia Sulfate somev tions in conclus Corro tems. E tion, 19 Deal ide, at acidity discuss —BLR Meta Harbon Eng., 2 Corro problem station examin The u sprayed ganic protect scrib Mag Tanks Air Co May. Mag sion o tanks action metal magne rod ta is con Life i tanks drawn Co.—1 Corro Coolin 4, (194 A su Aeron P. F. (1948) The posits. So. C (1948) Diso with t which conde played boiler Mai DeFlo 27, No Con piping



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corrosion of tanks; testing of sucker rods and tubing; code of metallurgical terms for ferrous alloys and other topics. Appendices give corrosion-test results for various alloys and coatings in gas-condensate wells, obtained by three companies.—BLR.

**The Statistics of Boiler Embrittlement.** C. D. Weir. *Trans. ASME*, 70, 253-256 (1948) Apr.

The methods of mathematical statistics were applied to the results of experiments carried out with Schroeder detector units. It was shown that differences in composition of the feedwaters with regard to hydroxide, chloride, silica, oxide, and phosphate do not influence materially the cracking susceptibility. Sulfate was found to stimulate cracking somewhat when present at concentrations in the region 200-600 ppm. Other conclusions are summarized.—BLR.

**Corrosion: Its Effect in Boiler Systems.** Part II. Robert L. Reed. *Combustion*, 19, 43-49 (1948) June.

Deals with corrosion by carbon dioxide, ammonia and hydrogen sulfide; acidity; and certain physical factors, discussing corrective measures for each.—BLR.

**Metals in Service.** P. M. Hess, Safe Harbor Water Power Corp. *Iron Steel Eng.*, 25, No. 6, 65-76 (1948) June.

Corrosion and other deterioration problems in the use of metals for power stations, turbines, water gates, etc., are examined with the aid of illustrations. The use of inhibitors, lubricants, hot sprayed zinc, cathodic protection, organic coatings and stainless steels for protection against deterioration is described briefly.

**Magnesium Rod Protects Hot Water Tanks from Corrosion.** *Heating, Piping & Air Conditioning*, 20, No. 5, 206 (1948) May.

Magnesium alloy rod lessens corrosion of hot water tanks. Rods protect tanks from destructive electrolytic reaction set up between water and tank's metal surface. High driving voltage of magnesium reverses current flow and rod takes corrosion attack. Magnesium is consumed and protects tank walls. Life in galvanized hot water storage tanks dependent on rate current is withdrawn from rod. Mfd. by Dow Chemical Co.—INCO.

**Corrosion of Metals in Aircraft-Engine Cooling Systems.** *Bull. Electrochem. Soc.*, 4, (1947) Nov.

A summary of Australian Council for Aeronautics Rep. No. ACA 24, 1946, by P. F. Thompson. (See *Met. Abs.*), 15, 38 (1948).—MA.

**The Prevention of Turbine-Blade Deposits.** G. C. Daniels, Commonwealth & So. Corp. *Combustion*, 20, No. 1, 33-35 (1948) July.

Discussion of trouble-free experience with turbines in a number of plants in which deaeration is accomplished in the condensers, evaporated make-up is employed and no treatment is given the boiler water.—INCO.

**Maintenance of Cooling Towers.** J. G. DeFlon, Fluor Corp., Ltd. *Petro. Ref.*, 27, No. 5, 145-149 (1948) May.

Control on rate of scale deposition in piping and on exchanger tubes is con-

trolled by pH of cooling tower water. Little or no scale deposit occurs when pH is less than 7. It is best to keep pH between 6.5 and 7, with the addition of a corrosion inhibitor to the system. Fan blades used are classified into fabricated carbon or stainless steel, cast aluminum, and airplane wing section.—INCO.

**Station Design and Material Composition as Factors in Boiler Corrosion.** R. B. Donworth. ASTM. Preprint No. 106, 8 pages (1948).

Shows the physical relationship of the materials and the influence of design on both corrosion and erosion and the subsequent carrying of the products into the boiler.—BLR.

**Condenser Tubes Made from Cupro-Nickel Alloy.** *Mat. & Meth.*, 27, No. 5, 121 (1948) May.

A copper-nickel condenser tube for installations where severe operating conditions are encountered has a nominal composition of 88.5% copper, 10% nickel and 1.5% iron. Alloy was developed by the British Non-Ferrous Metals Research Association. Under certain operating conditions copper-nickel affords added service and might prove more economical than either Admiralty or aluminum brass. Revere has had test installations of low copper-nickel in operation for periods up to four years. New condenser tube is recommended for marine and utility installations, encountering high velocities, high temperatures, brackish or salt water and bad pollution. It is not subject to dezincification. Mfd. by Revere Copper & Brass, Inc.—INCO.

**Chemical Descaling of Boilers.** W. J. Sinton, *The Australian Engineer*, 51-54 (1948) Mar. 8.

It has been known for some time that scale is removed from boilers by the alkali-phosphate system of internal boiler water conditioning. A typical case recalled by the author is that of a Babcock and Wilcox boiler with a capacity of some 20,000 lb. per hour. This boiler has been purchased second-hand from a country district and the tubes were lined with a scale at least 1/2 inch thick, probably more in parts. After twelve months internal alkali-phosphate conditioning, a large proportion of the scale had been removed in suspension through the blowdown and the balance was removed without effort by a turbine. Attempts to remove the scale by mechanical means prior to treatment had to be abandoned as the cutters had no effect. Descaling of evaporators in ships with alkali-phosphate mixtures has proved a reasonable proposition. The method is simple and involves filling the evaporator with water, adding a predetermined quantity of the chemicals and stewing for twelve to twenty-four hours at a gauge pressure of 5-10 lb. per sq. in. Regarding the cleaning of evaporators, there are two schools of thought, one which believes in descaling the evaporator as a unit and the other which believes that only the coils should be descaled, and this is done by removal and submersion in a bath of inhibited hydrochloric acid. This same school believes that the shell of the evaporator should be left scaled up as a protective measure; of course there is a case for and against. At face value this theory might be applicable when fresh water is being evaporated; however, with sea

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water, bearing in mind the corrosion due to the breakdown of magnesium chloride, there is a strong element of doubt. The application of acid descaling is simple. The first step in the consideration of scale removal is an examination of the scale. Naturally the sample is important and should be representative of the hardest and most dense scale in the equipment. The simplest and most practical examination consists merely of submerging the section of tube or piece of scale in the solvent; observation will readily indicate whether or not it is effective. The concentration can be changed so as to obtain the lowest concentration consistent with dissolving or disintegration of the scale.—Marine Eng.

### SELECTED BIBLIOGRAPHY ON SALT SPRAY TESTING

By Lorraine R. Voigt

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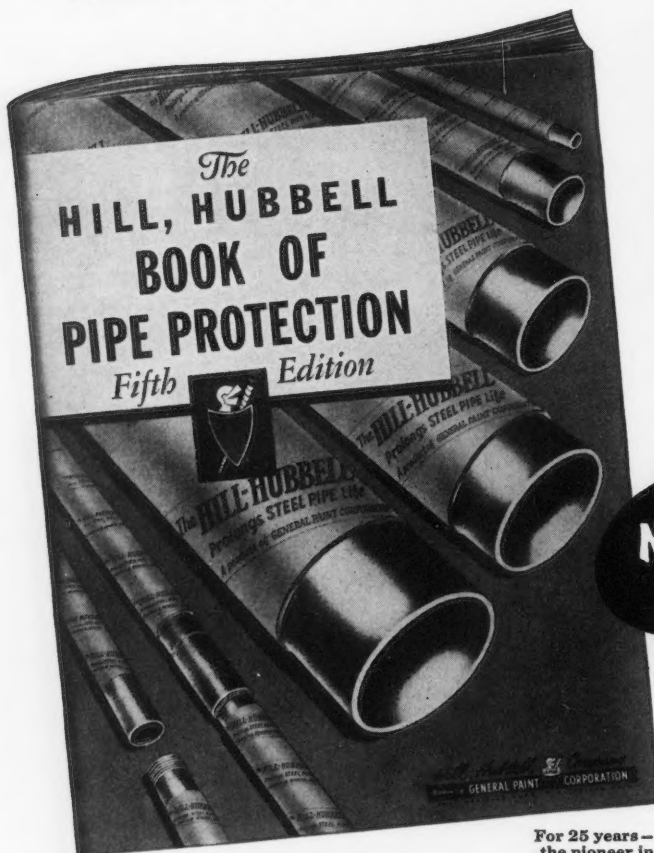
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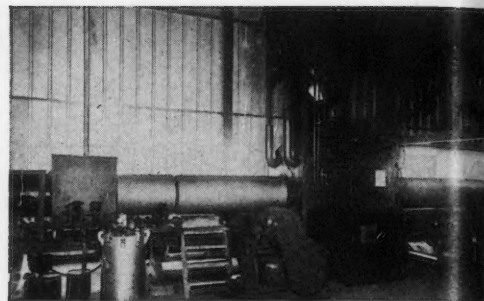
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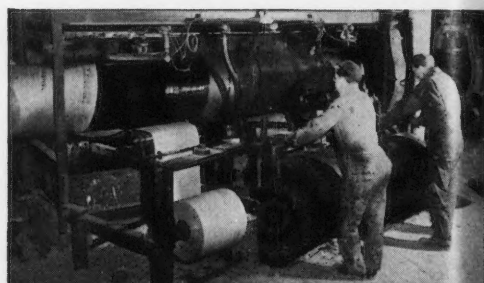


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